MODERN ELECTRO THERAPEUTICS

STRONG

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Essentials of Modern Electro-Therapeutics

An Elementary Text-Book on the Scientific Therapeutic Use of Electricity and Radiant Energy

Second Edition. Rewritten and Enlarged

by

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102 Illustrations in the Text

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PREFACE TO THE FIRST EDITION

Physicians who are familiar with the remarkable results which have been obtained from the scientific therapeutic use of electricity, often express surprise at the ignorance of this subject on the part of the majority of general practitioners. In lecturing on electro-therapeutics at Tufts Medical School the author has frequently been interrogated by his students as to the reason for the intense prejudice often freely expressed by prominent members of the profession against electricity as a therapeutic agent. He has also been asked, "Why do so few medical colleges include courses in electro-therapeutics in their curricula?" and, "Why are so many physicians uninformed regarding the wonderful advances which are being made in our knowledge of electricity and its relation to biology and medicine?" After mature consideration the author has arrived at the following conclusions, or reasons for the professional prejudice against electro-therapeutics:

First.—Many consider electro-therapy as a special school or form of sectarianism and avoid it as irregular practice.

Second.—The extravagant claims of quacks and misguided enthusiasts, and the unscientific character of many of the articles on electro-therapeutics which have appeared in contemporary medical journals, have disgusted many of the more conservative members of the profession.

Third.—The absence of a simple and reliable elementary text-book has been the greatest, and in some cases, the only reason for the exclusion of electro-therapeutics from the curricula of medical schools.

In the present work the author has endeavored to produce a text-book of the above character, not only for students in medical schools, but for the individual practitioner who wishes to learn the theory and practice of electro-therapeutics.

The advent of the *electron theory* has given us a new standpoint from which to study our environment, and has proven that all phenomena, whether physical, physiological or chemical, are in reality due to the movement of electrical charges, or *electrons*. In the chapter on "Physiology from an electrical standpoint," the author has endeavored to present old facts in this new light which has recently illuminated the whole domain of science.

That this little book may help some of his professional brethren to the understanding of many practical problems which he has been obliged to work out in the course of ten years devoted to the study of electro-therapeutics, is the earnest hope and desire of

THE AUTHOR.

BOSTON, MASS.,

PREFACE TO THE SECOND EDITION

It is now over ten years since the publication of the first edition of this book. In preparing the present edition the work has been entirely rewritten, corrected and modernized. Much additional matter has been added which it is hoped will make the work a practical handbook for the general practitioner as well as a text-book for medical students.

The author acknowledges his indebtedness to the many authorities consulted, especially the works of Neiswanger, Snow, DeKrafft, Eberhart, Sturridge, Morse and Tousey. He wishes also to tender his thanks to the various firms who have supplied illustrations of apparatus, and especially to Mr. Jacob J. Lowe, who kindly furnished the illustrations and material used in the description of the use of the X-rays in Dentistry.

FREDERICK FINCH STRONG.

BOSTON, MASS.

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CHAPTER I

MODERN THEORIES OF MATTER AND FORCE

1. Our idea of all physical and physiological processes have been revolutionized and greatly amplified by the recently discovered *"Electron theory,"* which teaches that all forms of matter are composed of *Negative* and *Positive Electricity,* and *nothing else.*

2. The unit of substance is the *"Electron"*—a minute point or center of *negative electricity.*

3. According to the atomic theory, all substance is formed of minute particles called *"Molecules,"* which are constantly

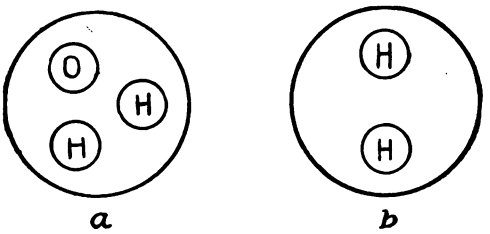


FIG. 1.—*a.* Water molecule of three atoms; H_2O.
b. Hydrogen molecule; two atoms.

swinging through definite orbits, and which are separated by relatively large spaces.

4. Molecules are usually composed of two or more *"Atoms."* The atom does not exist in a free condition except during chemical action, when molecules are broken up and their atoms reunite into different molecules.

5. *Chemistry* is the study of the above process, and is based upon our knowledge of the nature and tendency of atoms to combine to form molecules.

6. An *Atom* consists of a certain number of *negative electrons* floating or suspended in a sphere of *positive electricity*. The nature and atomic weight of the different chemical elements depends upon the number of electrons to the atom; Hydrogen, the lightest element, has about 1,000 electrons to the atom, its atomic weight being 1; Radium, one of the heaviest of elements, has about 200,000 electrons to the atom, and an atomic weight of 225.

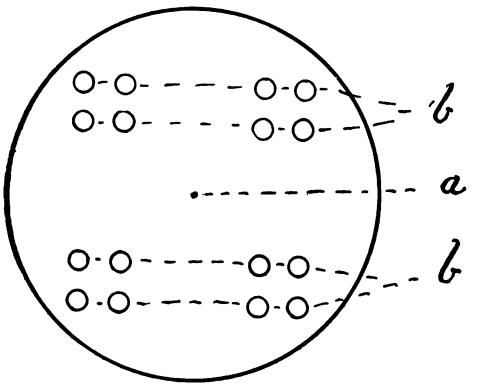


FIG. 2.—HYPOTHETICAL STRUCTURE OF AN ATOM.

a, Center of positive attraction. *b*, Groups of negative electrons, symmetrically arranged

7. The *Electron,* or *unit of negative electricity,* may exist independently of the atom, and the various forms of electrical currents result from the passage of streams of electrons through conducting substances.

8. *Positive electricity,* on the other hand, does not manifest an independent existence, being always associated with (*negative*) *electrons* in the *atom.*

9. The *unit of positive electricity* is the *"Positive Ion"* —an atom from which one or two of its electrons have

been temporarily withdrawn, leaving a preponderance of the positive electrical influence.

10. In the neutral atoms of the molecules, the positive influence is just balanced by the combined negative influence of their component electrons.

11. The atoms of certain chemical elements, notably the *Metals* and *Bases,* may be *temporarily deprived* of one or more *electrons* and they then become "Positive Ions." (See above.)

12. Atoms of *acid-forming elements* readily *attach to themselves* one or more *extra electrons,* and become for the time being *"Negative Ions."*

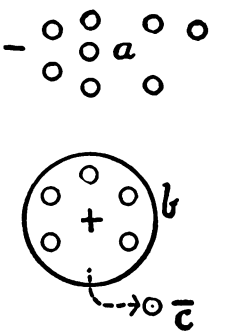


FIG. 3.—*a,* Negative Electrical Units, "Free Electrons." *b,* A Positive Electrical Unit, or Positive "Ion," being an atom which has lost a negative electron.

13. From a consideration of the above statements it will be seen that the production of *chemical reactions* between different substances result from the conversion of the neutral *molecular atoms* into *ions;* or to put the matter tersely, *"Ionization must precede chemical action."*

14. *Ionization* is brought about by the increased vibration of the atoms and molecules, resulting from the application of some external vibratory force, transmitted in the form of *ether waves,* or *"radiant electrical energy."*

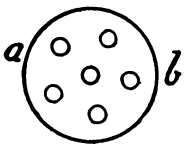


FIG. 4.—*a,* A Negative Ion, being an atom having normally five electrons, which has temporarily taken up one electron.

15. The *"Ether"* is a hypothetical elastic medium *filling all space;* including the inter-atomic and inter-electronic spaces, as well as those which separate the most distant fixed stars.

16. *"Radiant energy"* is motion, or force transmitted by the ether in the form of *"waves"* or *"transverse vibrations."*

17. These *"Ether waves"* are produced solely by the periodic *vibration* or *rotation of electrons.*

18. Motion or vibrations of *collections of molecules* or *masses* are called *"Mechanical movements,"* and do not produce radiant waves in the ether. A tuning-fork, for example, sets up mechanical vibrations or *Sound waves* in the air, but does not disturb the surrounding ether. A lighted candle, on the other hand, gives out radiant ether waves of *Light* and *Heat,* as a result of the intense vibrations of electrons in the flame; yet it produces no mechanical waves in the air.

19. The electrons in the different kinds of atoms have different rates of vibrations, and consequently produce ether waves of different *frequencies* and *wave-lengths.*

20. The slowest, longest ether waves known at the present time are called *"Hertz waves,"* and result from the vibrations of electrons in the *spark-discharge of a "Leyden jar."*

21. Higher in the scale come the *"Heat waves,"* caused by the electronic vibrations attending chemical combinations; or by the increased motion of atomic electrons resulting from collision or friction between moving masses. In short, *wherever friction occurs, heat waves are produced.*

22. Next in order are the *Light waves,* which result from the rapid vibration of the electrons of matter in the so-called *luminous state,* resulting from combustion, electrical discharges, etc. The term *"Light"* is restricted to about one octave, comprising vibrations between 450 million-millions (Red light) and 780 million-millions (Violet light); vibrations below and above these limits do not affect the retina of the human eye.

23. Between the upper limit of vision and a vibration of one thousand-million-millions are the so-called *Ultra-violet rays,* which affect photographic plates, discharge electrified

bodies and produce chemical changes in living tissues. Certain sensitive substances, such as *Willemite, Calcium Tungstate,* etc., give out light waves when exposed to ultra-violet vibrations; this phenomenon is called *Fluorescence.*

24. The most rapid form of ether vibrations yet studied are the X-ray of Roentgen, which result from the sudden stoppage of free electrons moving at a high rate of speed in

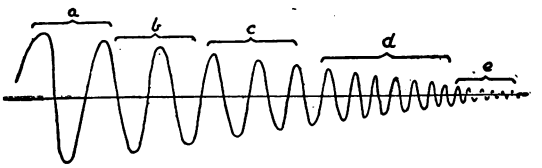


FIG. 5.—DIAGRAM INDICATING WAVE LENGTH AND FREQUENCY OF KNOWN FORMS OF RADIANT ENERGY.

a, Hertz Waves. *b,* Heat Waves. *c,* Light Waves. *d,* Ultra-violet Rays. *e,* Roentgen ("X") Rays.

an exhausted bulb at a pressure of one-millionth of an atmosphere. The X-rays affect photographic plates like light, cause phosphorescence in sensitive substances, and possess great power of penetration; the X-rays are absorbed by solid bodies in proportion to the density of the latter; this property is the basis of *"Radiography,"* by which shadow pictures of the bones, etc., are obtained on photographic plates. Frequent or long exposures to X-rays cause grave effects on the nerves and vital resistance of the tissues of the body, followed in a week or more by severe inflammation and necrosis.

CHAPTER II

THE FUNDAMENTAL LAWS AND PRINCIPLES OF ELECTRO-PHYSICS

1. *Electricity* is a term applied to the phenomena which result from the movement of *electrons* through *masses.*

2. Substances are divided into two classes:

(a) *Conductors* of electricity.

(b) *Non-conductors* of electricity, or *Insulators.*

Conducting bodies, such as metals, allow electrons to move through them as water through a pipe. Non-conducting bodies resist the passage of electrons.

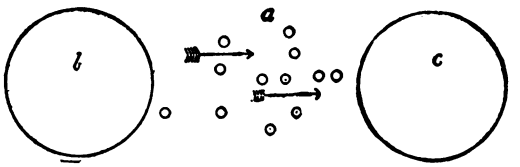


FIG. 6.—*a,* Group of Electrons moving from the mass (*b*) to the mass (*c*). *b,* Remains *positively* charged. *c,* Becomes *negatively* charged.

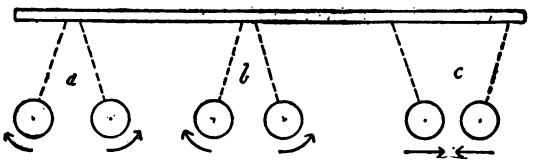


FIG. 7.—*a, b,* Bodies of *Like Charge* (or polarity), showing repulsion. *c,* Bodies of *Unlike Charge,* showing mutual attraction.

3. A mass from which electrons have been temporarily withdrawn is called a *Positively-charged body;* a mass to

which electrons have been temporarily added is called a *Negatively-charged body.*

4. Bodies having *like charges repel* each other; bodies having *unlike charges attract* each other.

5. A stream of electrons flowing through a conductor is called an *electrical current.*

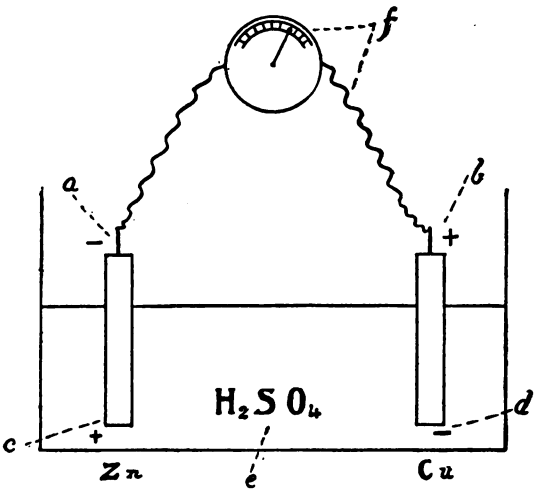


FIG. 8.—SIMPLE BATTERY CELL.

a, Negative *Pole. b,* Positive *Pole. c,* Positive *Plate. d,* Negative *Plate. e,* Electrolyte (dilute Sulphuric Acid). *f,* External Circuit, with galvanometer indicating current.

6. An instrument capable of maintaining an electrical current in a conductor is called an *electrical generator.*

7. A generator is in reality a *transformer of energy:*

(a) A generator which transforms the energy of *chemical action* into electricity is called a *battery.*

(b) One which converts *heat* into electricity is called a *thermo-electric generator.*

(c) A generator of electricity from *mechanical force* or *friction* is called a *static machine.*

(d) A generator which converts *mechanical force* first into *magnetism* and then into electricity is called a *magneto,* or *dynamo-electric machine.*

8. The simplest form of *battery* consists of a plate of copper, and a plate of zinc covered with mercury, immersed in diluted sulphuric acid; if the zinc and copper be connected by a conducting wire, chemical action will commence in the solution, the zinc being gradually dissolved in the sulphuric acid, forming zinc sulphate and hydrogen gas; the chemical process causes a withdrawal of electrons from the copper plate, an equal number of electrons being simultaneously forced into the zinc plate; and in this way a continuous *uni-directional electrical current* or *stream of electrons* flows through the metallic conductor from the zinc to the copper plate.

9. The direction of the electronic stream in the solution is therefore opposite to that in the conducting wire, and in this way a complete circular path or *circuit* is formed. The copper plate from which the electrons flow in the solution is called the *negative plate;* its upper extremity to which the conducting wire is attached is called the *positive pole* of the battery; the zinc being the *positive plate* and its upper terminal being the *negative pole.* These terms were applied years ago when electricity was believed to flow from the positive to the negative pole, and from the positive to the negative plate. We now know, however, that the stream of electrons really moves in the *reverse direction,* that is, from *negative* to *positive.* This fact should be borne in mind in order to avoid confusion.

10. A stream of electricity flowing through a conductor possesses attributes and properties analogous to those of a stream of water, falling from a height or flowing through

a pipe; in the latter instance the amount of water flowing through the pipe in a given time, and the size and diameter of the stream, would depend upon the *size, length* and *resistance* of the pipe, taken in connection with the *speed of the stream,* or the *pressure* which causes it to flow. Similarly, electricity of a given *pressure* or *potential* will

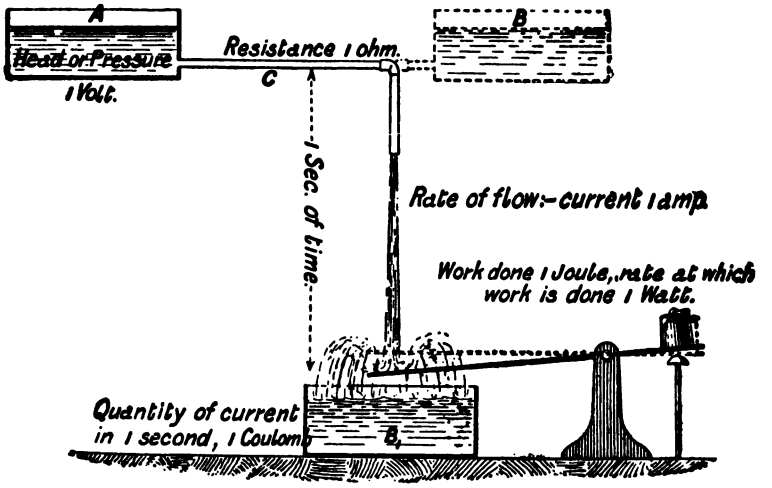


FIG. 9.—DIAGRAM SHOWING ANALOGY BETWEEN FLOWING WATER AND A CURRENT OF ELECTRICITY.
(From Williams' High Frequency Currents.)

create a current of a certain *volume* or *intensity* in a conducting path or circuit of a given *resistance.*

11. (a) The electrical unit of pressure or potential is the *"Volt."*

(b) The electrical unit of *volume* or *intensity* is the *"Ampere."*

(c) The electrical unit of resistance is the *"Ohm."*

12. The Volt is to an electrical current what the pound

per sq. in. is to a stream of water; it gives us an idea of the electrical pressure; that is, the *"Electro-motive force."* In physics this term is represented by the abbreviation "E. M. F."

The maximum pressure produced by a single battery, such as described in Section 8, is approximately one Volt.

13. The Ohm, or unit of resistance, is represented by a column of mercury one meter high and one millimeter in diameter.

14. A pressure of one Volt acting on the resistance of the above mercury column, will cause a current of exactly one Ampere to flow through the latter.

15. If two of the three factors, voltage, amperage and resistance, are known, the third factor may be found by the use of a formula called *"Ohm's Law."* This formula may be stated in three ways, as follows:

$$C = \frac{E}{R}\ ;\ R = \frac{E}{C}\ ;\ E = CR;$$

in which,

"C" = *Current volume in amperes.*
"R" = *Resistance in ohms.*
"E" = *Electro-motive force in volts.*

16. Batteries may be connected in two ways, called *series* or *cascade* and *multiple* or *parallel.*

17. If a number of cells—say five—are linked by short wires so that the positive pole of one cell is joined to the negative pole of the next, they are said to be in *"series";* and the current obtained from them will be of the same amperage as that from a single cell, while the voltage will be five times as great.

18. If, on the other hand, all the positive poles of the

above five cells be joined to one end of a circuit, while all the negative poles are joined to the opposite end, the batteries will be in "multiple" or "parallel"; and the current

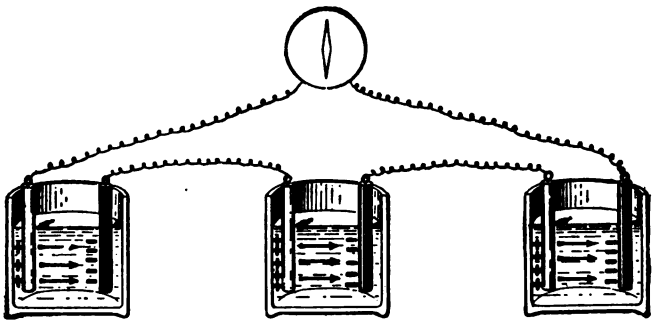


FIG. 10.—BATTERIES IN SERIES (Williams)

generated will have five times the amperage, but the same voltage as that produced by a single cell.

19. A *Static machine* generates a continuous electrical current of high voltage and low amperage. The older forms

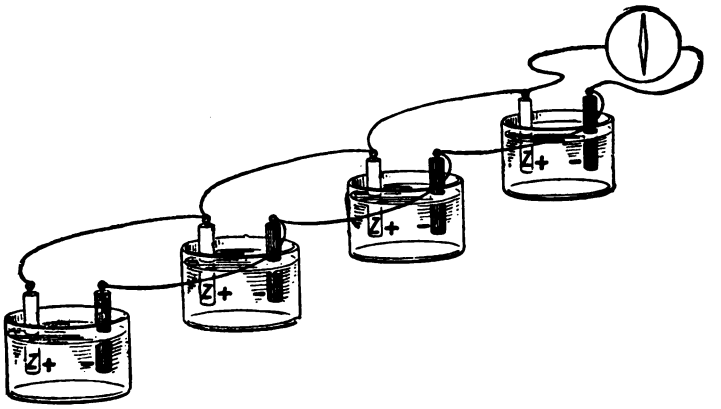


FIG. 11.—BATTERIES IN PARALLEL (Williams)

consisted of glass plates revolving in contact with silk-covered rubber pads; the friction caused electrons to be drawn from the surface of the glass into the silk; and the positive charge thus imparted to the surface of the revolving disk was drawn off by stationary brass combs or *collectors,* attached to an

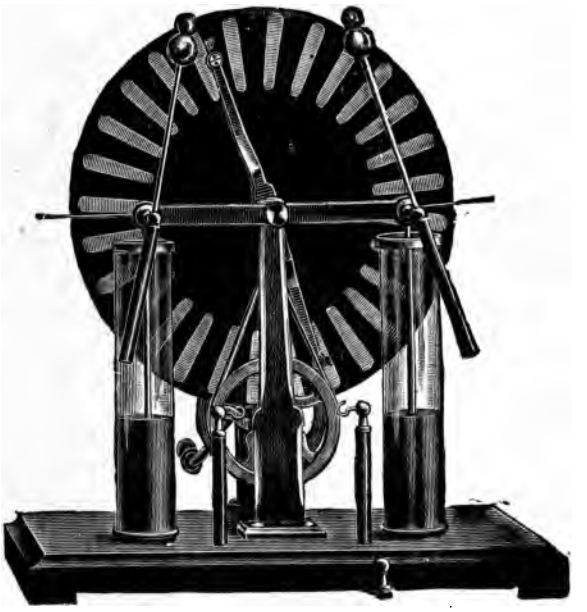


FIG. 12.—A SMALL STATIC MACHINE OF THE WIMHURST TYPE (Williams).

insulated brass sphere called the *"prime conductor";* when the hand was brought within a short distance of this conductor, a bright spark was produced and a transitory current of high voltage flowed through the body into the ground. The currents from a static machine will gradually leak away into the air from *metal points* or *edges,* but do not readily escape from *rounded surfaces* unless a conductor is brought

near them; hence, points are used on the collecting combs, while the prime conductor is spherical or oval.

In the modern static apparatus, such as the *Holtz machine,* an *initial charge* from a small frictional apparatus is communicated to a paper sector mounted upon a stationary glass plate; a circular glass disk revolves in front of the stationary plate, and when opposite the paper sector is charged inductively;—the *front* of the disk being charged *oppositely* to the sector, the *"like-charge"* being repelled to the *back* of the disk, where it is drawn off by a grounded collecting comb; the single charge now remaining in the disk is then drawn off by a second comb connected to one of the terminals of the machine. In this way a powerful, continuous current is produced, the process being known as *electro-static induction.* The charges produced on the glass plate are formed of *negative* and *positive ions,* rather than *free electrons,* as in the case of battery currents.

20. The production of electricity in the Holtz machine by electro-static induction is an application of the principle of the *"condenser,"* or *"Leyden jar."* This device consists, in its simplest form, of a *glass plate* which separates *two metal plates* of slightly smaller area. If a negative charge be communicated to one of the metal plates, negative ions will be distributed over the adjacent surface of the glass. These ions act inductively through the glass plate, converting the particles on its opposite surface into negative and positive ions, attracting the "unlike" positive ions into the second metal plate. If the latter be temporarily connected to a grounded wire the negative charge will be driven into the earth, leaving the condenser charged on the one side with the *negative,* and on the other with *positive electricity.* In the familiar type of condenser, known as the *Leyden jar,* a wide mouth bottle is used instead of a glass plate, coated on the inside and outside with tin-foil, the charge being

communicated to the inner by means of a brass ball and chain supported by the stopper of the bottle.

21. If a wire be connected with the outer coating of a Leyden jar, and its other end brought near the brass ball connected with the inner coating, a ***bright white spark*** will

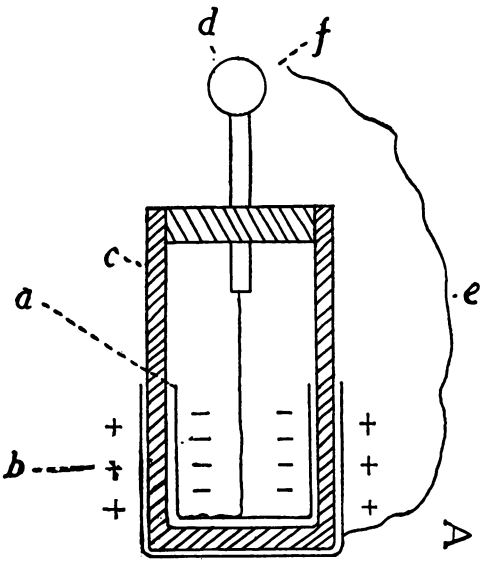


FIG. 13.—LEYDEN JAR, OR CONDENSER.

a, Inner Coating. *b*, Outer Coating. *c*, Glass Jar. *d*, Brass Ball Terminal. *e*, Discharging Wire. *f*, "Spark-gap."

be formed between the knob and wire, and a current or stream of electrons will flow through the latter. This stream of electrons seems to *acquire momentum,* and instead of ceasing when electrical equilibrium has been established, the current will continue until the jar is charged in an *opposite direction;* the coating which was originally positive is now negative, and vice versa. All this takes place during

an extremely small fraction of a second, before the incandescent air particles in the path of the spark have had a chance to cool, and a second discharge immediately ensues in which the electrons move through the wire in a direction opposite to that of the *initial discharge;* in this way a *series* of *alternating discharges* or *electrical oscillations* are set up in the circuit formed by the *wire,* the *"spark-gap,"* and the *two coatings of the Leyden jar;* each oscillation being less powerful than the preceding one, so that they gradually die away and the jar is left in an uncharged condition. The electrical oscillations may be compared to the motion of a fluid in a glass "U" tube when air pressure has been applied to one arm of the tube and suddenly released;—the fluid will alternately rise and fall,—each movement being slightly less than its predecessor,—until equilibrium is established.

22. If a coil formed of a definite number of turns of coarse wire be included in the discharging circuit of a Leyden jar, the oscillations will not die down so rapidly and the number of alternating impulses resulting from each primary condenser discharge will be much greater than in a circuit without the coil.

23. The frequency or number of oscillations per second depends on the size or *"capacity"* of the condenser. An inductance coil of a definite size and number of turns will *augment* or *prolong* the series of oscillations produced by each primary discharge of a condenser of given capacity, and we then have what is called a *"tuned system."* When such a system is connected with a device for *re-charging* the condenser as soon as each set of oscillations die out, the arrangement is called a *"high-frequency apparatus";* and the inductance coil is known as a *"d'Arsonval high-frequency solenoid."*

24. When *ions,* or *electrons* are suddenly brought from a condition of rest to one of motion, or vice versa, a *magnetic*

field of force is transmitted through the surrounding ether, which affects the electrons in any adjacent conductor; thus a sudden rush of electrons through a coil of wire produces a similar transient movement in a second coil of wire wound concentrically with the first coil. This is called *electro-magnetic induction.* The electrical impulses also produce inductive effects upon adjacent convolutions of the coil in which they flow. This is called *self induction.* We can

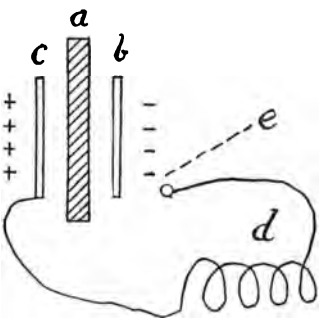


FIG. 14.—PLATE CONDENSER, WITH INDUCTANCE COIL.
a, Glass Plate. *b,* Negative plate. *c,* Positive Plate. *d,* Inductance Coil. *e,* Spark-gap.

cause this self induction to retard the passage of the current. A coil which is designed to *obstruct* the current by its self induction in this way is called an *"inductive resistance"* or *"choke coil."* Such coils are used to control or regulate commercial alternating currents in the same manner that coils of high "ohmic" resistance (Rheostats), are used to regulate *direct continuous currents.*

25. If to one end of the solenoid is attached a coil of fine wire in a single layer or spiral, and the second coil be *tuned* to the same *frequency* as the solenoid, the two coils are said to be in a condition of *"electrical resonance."*

The second coil is called an *"Oudin resonator,"* and from its free upper terminal a *current of high-frequency* may be obtained, of a *potential* or *voltage very much higher* than that of the *solenoid circuit.*

26. When used for therapeutic purposes, the solenoid and resonator are usually excited by two Leyden jars, which are charged from a Ruhmkorff coil, alternating current trans-

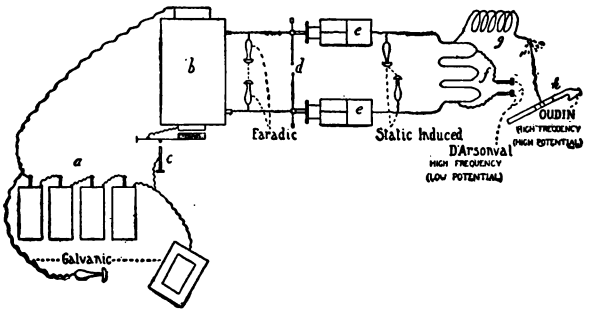


FIG. 15.—DIAGRAM OF A OUDIN-D'ARSONVAL HIGH-FREQUENCY APPARATUS, SHOWING INTERMEDIATE FORMS OF CURRENT.

a, Batteries in "Series." *b,* Induction Coil. *c,* Vibrator or Interrupter. *d,* Spark-gap. *e,* Condensers, or Leyden Jars. *f,* d'Arsonval "Solenoid." *g,* Oudin "Resonator." *h,* "Vaccum" Electrode.

former, or large static machine. The discharge from the resonator is necessarily *uni-polar.*

27. In order to obtain *bi-polar currents* of high-frequency and high potential, a fine wire coil, similar but smaller than the resonator, is used; but instead of being connected to the solenoid, it is slipped inside the latter, and the two are separated by a layer of insulating wax or oil. The high voltage current is produced in the fine coil through the *electro-magnetic induction* of the *oscillating electrons* in the *solenoid.*

28. The two coils just described constitute a *"Tesla-Thompson high-frequency transformer,"* the fine wire, or secondary coil, being commonly referred to as the *Tesla coil.* This type of apparatus is usually associated with a condenser formed of a number of flat plates of glass or mica, separated by sheets of tin-foil, and the charging current is obtained from a *step-up transformer,* having a *closed magnetic circuit,* excited by a commercial alternating current of low voltage and high frequency.

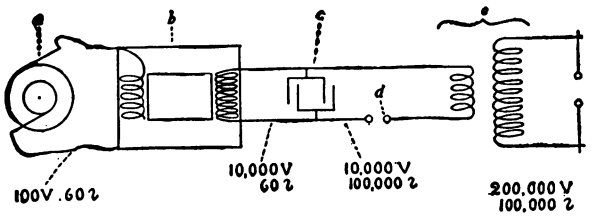


FIG. 16.—TESLA-THOMPSON HIGH-FREQUENCY APPARATUS.

a, Alternating Current Generator. *b,* "Step-up" Transformer. *c,* Condenser. *d,* Spark-gap. *e,* Tesla-Thompson High-Frequency Transformer.

29. The principle of electro-magnetic induction, exemplified in the Tesla coil, is employed in the transformation of currents of less voltage and frequency in a somewhat different manner. In the Tesla current a high voltage current is obtained by the *direct inductive action* of the high-frequency current in the primary solenoid;—in low frequency transforming devices the primary current first induces *temporary magnetism* in a *soft-iron "core,"* and this in turn, through the ether, induces the current in the secondary coil.

30. The term *magnetism* has been used to describe certain properties which are found in the element iron, and in several other metals in a less degree. When a current is

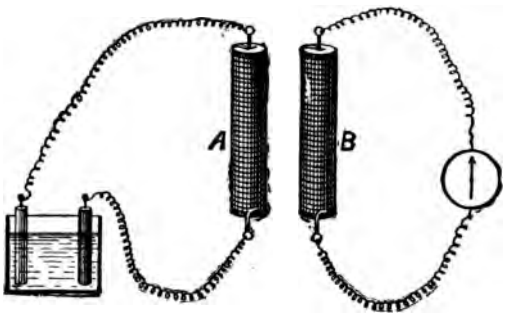


FIG. 17a.—MUTUAL INDUCTION.

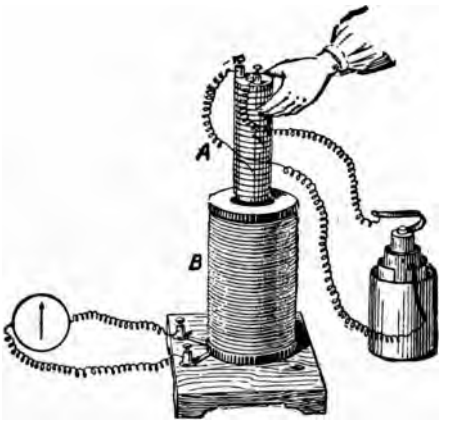


FIG. 17b.—ELECTRO-MAGNETIC INDUCTION.

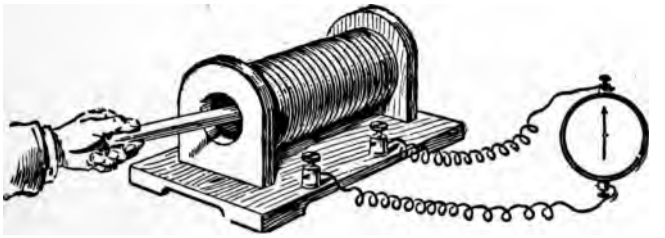


FIG. 17c.—MAGNETIC-ELECTRIC INDUCTION (Williams).

passed through a coil surrounding a bar of iron, the latter becomes temporarily magnetic through a rearrangement or polarization of its component particles. When the current ceases the atoms and the electrons resume their normal relation and in so doing set up *radiating ether waves* which induce a momentary current in a secondary coil wound outside the primary. If *steel* is used instead of *soft iron,* the electrons remain polarized and a *permanent magnet* results.

31. When such a magnet is introduced into a coil of wire, a current impulse is induced in the latter; when the magnet is withdrawn, a similar impulse is induced in the opposite direction. By moving a magnet in and out of a coil, or by revolving a coil between the poles of a magnet, a succession of alternate impulses is produced which constitute an *alternating electrical current.* By suitably arranging the revolving coil in reference to the magnet, the alternating impulses may be made to rise and fall smoothly and regularly like the waves upon the surface of a pond when a pebble is dropped into its center. The *electrical waves* so produced form what is called a *sinusoidal current.*

32. To transform an alternating current, so produced, from a low to a high voltage, it is passed through a primary coil wound upon one side of an iron core shaped like a hollow square; on the opposite side of the core is wound a secondary coil or longer and finer wire, in which the high voltage current is induced. If a high voltage alternating current be passed through the secondary coil, a current of low voltage will be induced in the primary coil. When used in this way the device is called a *step-down transformer;* when used to transform a low voltage current into one of high voltage it is called a *step-up transformer.*

33. To obtain a high voltage current from a continuous direct current of low voltage, a transforming device called an *induction coil* is used. This consists of a straight core

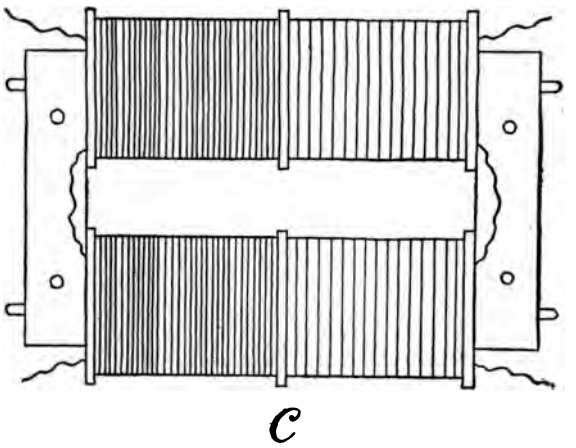


FIG. 18.—ALTERNATING CURRENT TRANSFORMER.

For "stepping-up" a current from 110 volts to 15,000 volts; coils are wound on a closed magnetic circuit of thin plates of "electrical steel."

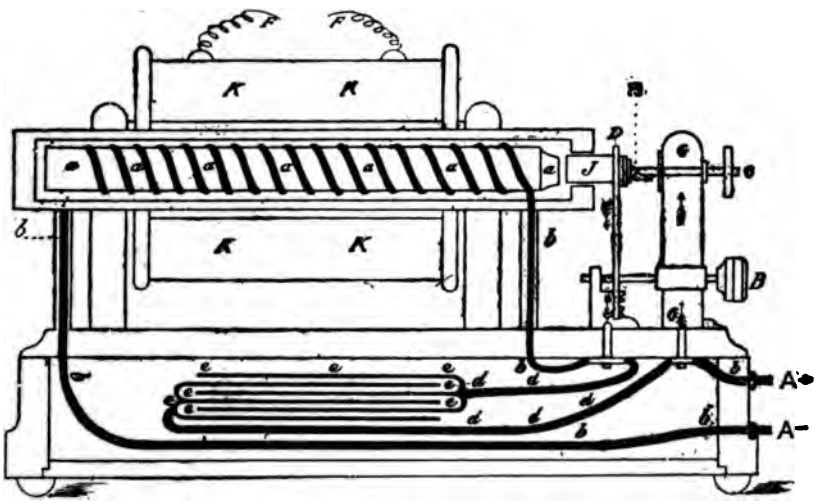


FIG. 19.—DIAGRAM OF INDUCTION COIL (Williams).

of soft iron, upon which is wound a coarse primary coil; over this, in turn, is wound a fine wire secondary coil. The direct current used to excite the primary coil is periodically interrupted in order to produce the inductive impulses.

34. The *Faradic coil* is a small form of induction coil used for therapeutic purposes. The primary current is

FIG. 20.—SMALL FARADIC COIL.

obtained from battery cells, and is interrupted by means of a spring vibrator actuated by the magnetism of the iron core. The secondary coil is made to slide over the primary so as to regulate the strength of the induced currents.

35. For the production of powerful high voltage currents for exciting X-ray tubes or high-frequency apparatus, a form of induction coil is employed which is known as the *Ruhmkorff coil.* Its secondary coil contains thousands of

feet of fine wire wound in thin sections or insulated layers. Its primary is usually excited by the 110-volt direct incandescent light current, which is interrupted by a *mechanical* or *electrolytic break.* A condenser, consisting of a

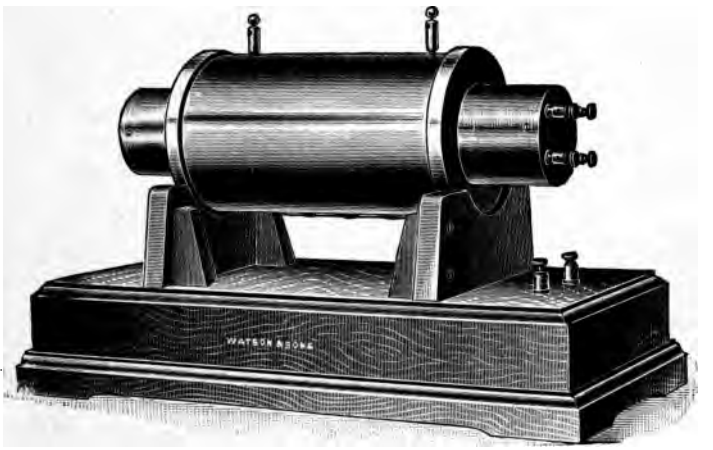


FIG. 21.—"RUHMKORFF" INDUCTION COIL.

number of sheets of tin-foil, separated by waxed paper, is usually mounted in the base of the Ruhmkorff coil for the purpose of absorbing or neutralizing the so-called *extra-current,* which is self-induced in the primary coil at each interruption of the current.

CHAPTER III

PHYSIOLOGY FROM AN ELECTRICAL STANDPOINT

1. The Human organism may be compared to a symphony orchestra; the organs representing the various instruments, while the individual players may be likened to the peripheral nerves and ganglia of each organ, controlled and supervised by the conscious intelligence through the central nervous system, analogous to the conductor or musical director.

2. Suppression or alteration of any one function disturbs the equilibrium of the whole body, just as a single instrument playing out of tune will destroy the harmony of an entire orchestra.

3. The growth and functional activity of the human body is maintained by the potential energy stored up in the food. This food is derived directly or indirectly from vegetable substances.

4. All energy comes primarily from the sun, largely in the form of radiant heat waves. This heat is absorbed by vegetable organisms, and is used to break up carbon dioxide, from the atmosphere, into carbon and oxygen. The carbon is combined with water to form the organized structure of the plant or tree. The oxygen is given back to the atmosphere. The radiant solar energy is thus transformed into potential chemical energy which is stored up in the carbon of the plant, on the one hand, and the freed oxygen on the other. It is this stored-up energy which is employed in the animal organism for the performance of the different

physiological functions. Thus the energy expended in lifting a weight involves the recombination in the muscle fibers of the carbon obtained from the digestion of food with atmospheric oxygen brought from the lungs by the red blood corpuscles.

A consideration of the above facts shows the fundamental difference between animal and vegetable organisms. The latter absorb the active solar energy and breathe CO_2, returning oxygen to the atmosphere and building up carbon compounds in which potential energy is stored. Animals, on the other hand, break down the vegetable compounds which are burned up in the cells of the organism with oxygen from the air, the stored-up energy being liberated in an active, or kinetic form, and carbon dioxide being returned to the atmosphere.

5. While the maintenance of health in the human organism depends apparently upon the digestion and absorption of food, and a proper supply of oxygen, there are other factors at work which medical science is only beginning to recognize; there is no doubt but that the whole scheme of creation involves the action of what we may call the *"Life force"* or *"Vital energy."* Through the action of this great Cosmic Force electrons are formed into atoms; atoms into molecules; molecules into crystals and chemical compounds; and these into the cells and bodies of plants, animals and man. We have no name for this force, but through its action the great Evolutionary Scheme goes on. In India they call it by a Sanscrit name,—*"Prana."* Here in the occident we have not yet officially recognized this force, but its existence cannot be denied even though we are as yet unable to measure it and harness it in the laboratory. Simple animal organisms like the amœba, and simple cells of the embryonic type, appear to possess the power of absorbing vital force from food and air and of using it in maintaining

their various functions of growth, reproduction, etc. When cells become highly specialized,—as for example the cells of muscle fibres,—they lose this power of direct self-vitalization and must be sustained by subtle stimulating forces carried to them from the nerve centers. It is generally conceded that these vitalizing, or "trophic" centers, are in the anterior horns of the spinal cord for the motor nerves and voluntary muscles, and, for the sensory nerves, in the posterior spinal roots. Hence, injury to a trophic center causes atrophy and loss of function in the corresponding nerves and muscles (as in infantile paralysis). The general distribution of the life force to unstriped muscle and to the visceral organs is largely through the sympathetic nervous system or some subtle "etheric body" intimately connected with it.

6. The following functions are concerned in the preparation and distribution of the food material and oxygen.

(a) The *Digestive system,* in which the food is mechanically softened and disintegrated and then rendered soluble by chemical ferments.

(b) The *Absorbent system,* in which the digested food is taken from the intestine and transferred to the blood stream.

(c) The *Distributory system,* including the blood vessels and lymphatics, which carry the absorbed nutriment to all parts of the body.

(d) The *Respiratory system,* comprising the lungs, which draw in oxygen, and the red blood corpuscles which carry this oxygen to all parts of the body.

(e) The *Excretory system,* which frees the body from the burned-up cell débris, and the products of

tissue combustion. The gas CO_2, is brought by the blood returning from the different parts of the body to the lungs where it is thrown off, while the red corpuscles are absorbing a fresh load of oxygen. Solid waste particles are picked up by the leucocytes, or white blood corpuscles, and carried to the spleen, where they are completely burned up. These leucocytes are the "police," as well as the "scavengers" of the body, picking up and carrying away disease germs or poisonous substances accidentally introduced through wounds. When any part of the body is cut or torn, these leucocytes form a wall, preventing foreign matter from gaining access to the blood stream; and in the same way they surround developing masses or colonies of disease germs, thus checking their development and protecting surrounding tissues. The little seed-like nodules which form in the lungs in the early stages of consumption are collections of the bacilli of tuberculosis which have been walled in by leucocytes in the above manner. These nodules are called *"miliary tubercles."*

The leucocytes also aid the body to throw off infectious disease by forming soluble chemical antidotes, which neutralize the poisonous products of the bacteria. Diphtheria antitoxin is an antidote of this kind formed by the leucocytes of the blood of a horse, which has been gradually *immunized* to poison obtained from diphtheria bacilli, artificially grown in the laboratory.

(f) All of the above functions are maintained and regulated by *vibrations* or *oscillations,* transmitted through the *nerves* of the so-called *sympathetic system;* which consists of a double chain of nerve

ganglia and filaments radiating from the great center, or collections of nerve cells in the abdomen called the *Solar plexus.*

7. In the last paragraph we have considered the various processes by which the cells and tissues of the human body are supplied with the potential energy necessary for the performance of their respective functions; and incidentally we have explained the manner in which the organism is protected from the action of disease germs and their poisonous products. We will now discuss the functions which involve the dispersion of the energy taken in with the food and air.

8. The most important of these functions has its seat in the muscular system, and involves the conversion of the potential energy supplied by the food, into active, or kinetic mechanical force. The muscular system comprises,—the *voluntary muscles,* which contract only under the influence of a conscious impulse, transmitted from the brain to the motor nerves through the spinal cord; and the *involuntary muscles,* which are independent of consciousness or volition; they are associated with the mechanical processes incidental to digestion, circulation and respiration. They are operated by vibrations transmitted largely through the nerves of the sympathetic system.

9. The sensory mechanism also involves the dispersion of stored-up energy. Through the various sensory nerves we are enabled to come into conscious relation with the objective world which we interpret through *Vibrations,* of different types and frequencies. Almost all parts of the body are provided with sensitive, bulb-like structures called *"tactile corpuscles,"* each of which is connected to a sensory nerve filament which passes through the spinal cord to the centers of sensation in the brain. These filaments pass through large nerve cells in the spinal cord which act like

batteries, supplying energy for the vibratory impulses which cause sensation.

The exact nature of sensory nerve impulses is not known. It is probable, however, that each sensory nerve with its terminal bulb acts somewhat like an electrical condenser, and that stimulation or irritation of the nerve-ends cause this condenser to discharge, producing oscillations of a definite frequency, varying in intensity or amplitude according to the degree of stimulation. Slight contact between the skin and a soft substance would set up faint oscillations, which would be transmitted to the brain and interpreted as a delicate tactile sensation; severe irritation or abrasion of the skin, on the other hand, probably causes a complete "short-circuiting" of the nerve condenser, resulting in oscillations of great intensity, which give rise to a conscious sense of local pain.

10. Finally, we have the so-called "special senses"—sight, sound, taste, and smell. The nature and range of the vibrations which affect the human ear and eye have been considered in a previous chapter. The frequency of vibration in the nerves of taste and smell has not been determined. They are closely allied to ordinary tactile sensations, but the various impressions are probably produced by contact with matter in an etheric or supergaseous condition (between the gas and the electron).

11. The various types of nerves, whether sensory, motor or sympathetic, transmit to their respective organs and tissues a peculiar vitalizing influence called *"Trophic force."* This action, which was formerly believed to possess a special system of nerve filaments, is now known to be a common function of all nerves; in other words, each nerve possesses a so-called *trophic center,* which continually supplies the nerve and its respective tissues with the peculiar vibratory force necessary for their growth and vital action. The trophic

centers of the motor nerves are in the anterior horns of the spinal cord. The sensory nerves have their trophic centers in small ganglia which lie just outside of the posterior roots of the spinal cord. The significance and importance of the trophic centers is shown by the study of diseases involving their degeneration. For example, in certain types of lateral sclerosis which involve certain trophic centers, the muscles corresponding to the latter *atrophy,* and practically disappear. In cases of motor and sensory paralysis, on the other hand, where the trophic centers are not affected, the muscles remain for a long time without much diminution in size.

CHAPTER IV

GALVANISM

1. In a previous chapter we have seen that radiant waves in the ether result not from the mere motion of electrons, but from vibrations or impulses involving the sudden passage of electrons from a state of rest to one of motion, or vice versa. In like manner, nerve vibrations are not excited by the passage of a constant current through the body, but are invariably produced by the *sudden increase* or the *interruption* of such a current.

2. If a number of battery cells be connected in series, and their terminal wires be connected to two wet sponge electrodes in contact with the human body, a continuous, unidirectional stream of electrons will flow through the latter. This is called a galvanic or constant current, and, as the voltage from the series of cells is relatively low, and the resistance of the body is very high, it will be seen by referring to "Ohm's Law"—(see Chapter II),—that the volume of such a current will be but a small fraction of an ampere.

3. This being the case, we employ in electro-therapeutics a unit of volume or intensity called the *"Milliampere,"* which is equal to one one-thousandth of an ampere.

4. The resistance of the human body is confined principally to the skin and averages from 2,000 to 5,000 ohms. It may be much less, or much greater than this, according to the condition of the skin, the nature of the electrodes, and the size of the surface that they cover. It is an important rule in galvanism, *that the resistance of the body*

be made as low as possible. This is accomplished by wetting the surface with a salt solution, after washing with soap and warm water, and by using electrodes having as large an area as is practicable.

5. In most instances, the constant current is used in the treatment of *local conditions,* and the terminal which is applied to the diseased area is called the *"active electrode."* This should be of small size in order to concentrate, or intensify, the local electrical action. The other terminal is

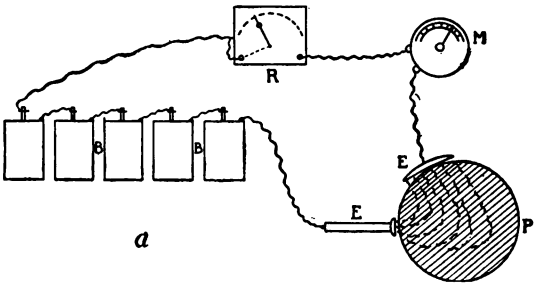


FIG. 22.—BATTERIES ARRANGED TO PRODUCE THE GALVANIC OR CONSTANT CURRENT.

B B, Cells in series. *R,* Variable resistance. *E E,* Electrodes. *P,* Body of patient.

attached to what is known as the *"passive, or indifferent electrode,"* which should be of large size so as to lessen the resistance. An efficient indifferent electrode can be made from a piece of block-tin or sheet-lead, having a binding post attached to one corner. This is wrapped with several layers of surgical gauze, soaked in salt solution, and applied to the abdomen of the patient. It can be molded to fit any other part of the body if desired. An equally good plan is to use a small tub of warm salt solution for the indifferent electrode, the feet of the patient being immersed in the conducting fluid.

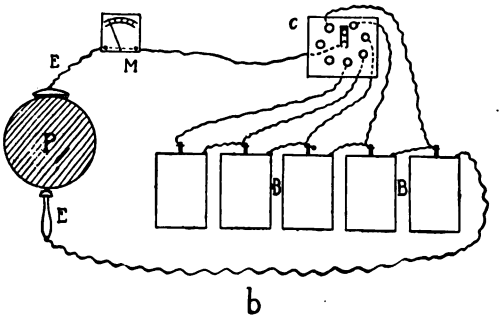


FIG. 23.—GALVANIC OUTFIT WITH CELL SELECTOR, *C*.

6. A galvanic current for therapeutic use may be obtained from battery cells connected in series, or from a 110-volt direct incandescent lighting current.

7. If batteries be used, they are connected in series, and the strength of the current is regulated by an adjustable rheostat. Another method of regulation is to connect the wires between each cell with the points of a rotary switch

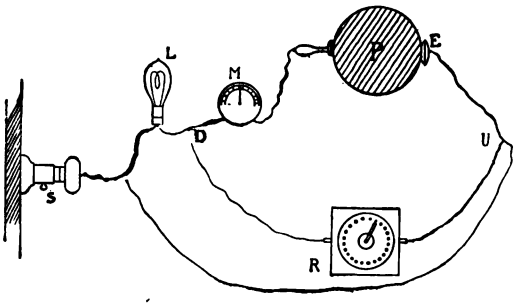


FIG. 24.—ARRANGEMENT FOR OBTAINING A GALVANIC CURRENT FROM THE 110-VOLT DIRECT CURRENT.

S, Lamp socket, plug and cord. *L*, 16 c. p. lamp which limits the flow of current. *D*, Point at which the current is divided into two "shunt" circuits. *M*, Mil-ammeter. *E E*, Electrodes. *P*, Patient. *R*, Variable Rheostat.

called a *"cell selector,"* which permits the use of any number of cells in series.

8. In order to adapt the direct incandescent light current for therapeutic use, a device called a *"shunt coil"* is used. The 110-volt current first passes through a small incandescent lamp and is then split into two parts, one of which

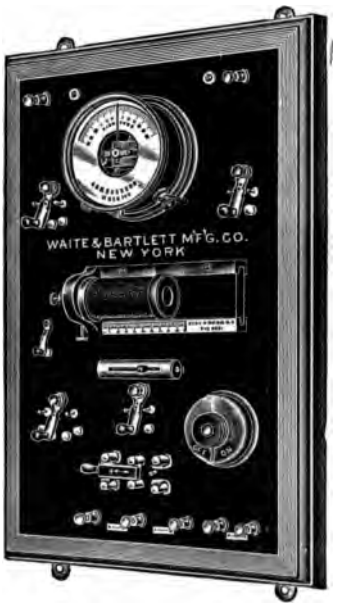


FIG. 25.—WALL PLATE FOR USE WITH 110-VOLT CURRENT.

passes through the shunt coil, and the other through the body of the patient, after which the two branches of the circuit re-unite and return to the mains. By varying the resistance in the shunt coil, a greater or less amount of current is diverted to the patient's branch of the current.

9. Every galvanic outfit should be provided with an instrument for measuring the amount of current which is

passing through the body of the patient. Such a device is called a *"Milliampere meter,"* which is commonly abbreviated to *"Mil-ammeter."* It consists of a galvanometer, having a permanent magnet with a pivotal coil between its poles. A pointer attached to the coil moves over a graduated scale; and the passage of a galvanic current through the coil causes a movement of the pointer corresponding to the strength of the current. The scale is graduated so as to indicate the number of milliamperes passing through the

FIG. 26.—PORTABLE GALVANIC OUTFIT, OPERATING AND DRY CELL BATTERIES.

patient. In some instruments a stationary coil is used, which acts upon the pivotal soft-iron armature, mounted between the poles of the magnet. In still another form of instrument, the current passes through a very fine platinum wire, which becomes heated in proportion to the volume of the electrical stream, the change in length thus produced causes the rotation of a delicate pivot carrying an indicating needle. The hot-wire meter, just described, possesses a great advantage over magnetic meters, as it may be used equally well for the measurement of a galvanic, alternating, or high-

frequency current. For this reason it has been styled the *"universal galvanometer."* The magnetic meters, first described, can be used only with a continuous or galvanic current.

10. In choosing a galvanic outfit, when the direct or

FIG. 27.—GALVANIC APPARATUS FOR USE WITH ALTERNATING CURRENT.

"Edison current" cannot be obtained, it will be necessary to employ batteries. For a stationary office outfit, wet cells of the carbon-cylinder type are generally used; the electrolyte or charging-fluid, consisting of a strong solution of ammonium chloride—("Sal ammoniac"). For most purposes from twenty to thirty cells will be sufficient. For a

FIG. 28.—HOT WIRE MIL-AMMETER.

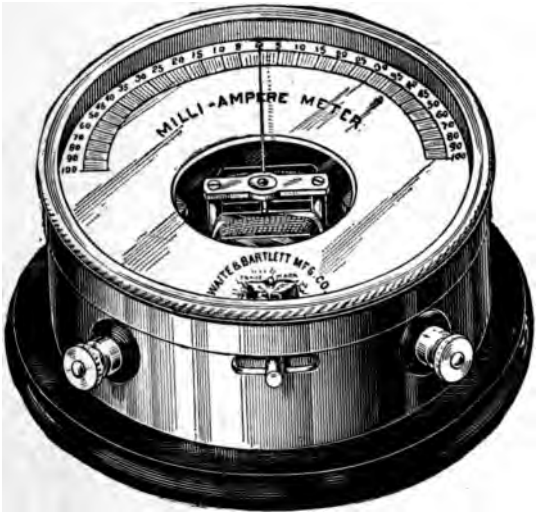


FIG. 29.—MAGNETIC MIL-AMMETER.

portable outfit, dry cells should be employed, such as are used with electric bells, and for automobile coils. These cells cannot be recharged, but can be replaced for a comparatively small sum. The so-called "chloride of silver dry

FIG. 30.—WALL PLATE FOR USE WITH 110-VOLT DIRECT CURRENT.

cells" are of very small size, and a battery of 100 cells can be carried in a case a foot square. A serious objection to their use, however, is their extremely high internal resistance, and they are suitable only for treatments which require a current of very small volume, such as electrodiagnosis and the removal of facial blemishes. They are

seldom used, small dry cells of the "flash light" type being employed in their place. In administering the constant current, the electrodes should first be applied and the current should then be very gradually increased from zero until the required strength or volume is indicated by the mil-ammeter. At the end of the treatment the current should be shut off in the same gradual manner. The therapeutic use of galvanism may be considered under the following heads:

(a) *General galvanization,*—when the current is used for its effect on the entire organism.

(b) *Local galvanization,*—where a circumscribed area is subjected to the physiological action of the positive or negative pole, according to the effect desired.

(c) *Positive electrolysis,*—in which local effects result from the chemical action of a zinc, copper or other electrically soluble *"Anode"* or *positive electrode.*

(d) *Negative electrolysis,*—being the local destruction of tissue by the alkaline products at the *"cathode"* or *negative electrode.*

(e) *Ionization,*—the local action of elements or medicinal acids or bases driven in as *"ions"* from either the positive or negative electrode. *Cataphoresis,* or *electrical osmosis,* involves the driving of medicines into the tissues by the *mass action* of the continuous current.

(f) *Interrupted galvanism,* in which the current is mechanically interrupted or broken into series of sharp impulses, somewhat resembling a primary faradic current.

11. *General galvanization* is used by some practitioners in the treatment of organic spinal diseases, obesity and diabetes. Large block-tin electrodes are used, covered with

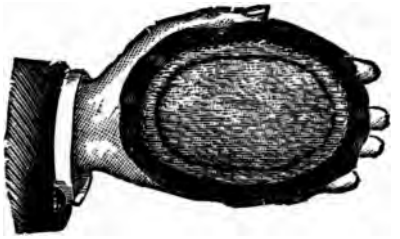


FIG. 31.—FLEXIBLE HAND ELECTRODE.

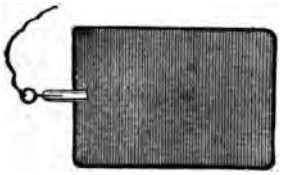


FIG. 32.—FLEXIBLE WIRE GAUZE ELECTRODE.

FIG. 34.—ZINC AND COPPER ELECTRODES (*Soluble*), FOR POSITIVE ELECTROLYSIS; WITH RUBBER-COVERED STEM.

FIG. 33.—SPONGE-COVERED HAND ELECTRODE.

gauze, wet with salt solution; the cathode being applied over the upper part of the spine, and the positive electrode over the abdomen. Twenty to fifty milliamperes are given, the duration of each treatment averaging twenty-five minutes.

12. *Local galvanization* is employed in a variety of diseases, such as neuralgia, rheumatism, and acute and chronic inflammation. In general, a small sponge-covered disk electrode is applied to the affected area, the indifferent

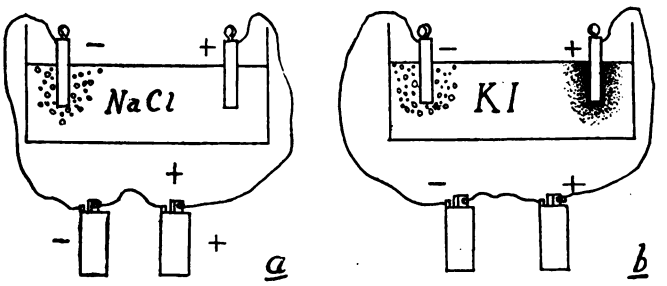


FIG. 35.—TESTS FOR POLARITY.
a, Sodium Chloride Solution with Hydrogen bubbles at Cathode.
b, Potassium Iodide Solution with Hydrogen at Cathode and Iodine at Anode.

electrode being of the usual type, described in paragraph 5. The choice of poles depends upon the nature of the diseased condition, the local effect of the positive pole being *sedative, hemostatic, germicidal* and tending to *relieve congestion.* The negative pole, on the other hand, *produces congestion, local stimulation* and *counter-irritation.*

13. *Positive electrolysis,* or metallic ionization, is mainly employed in diseases of the mucous cavities, more particularly those of the uterus and vagina. Electrodes of chemically pure zinc or copper are employed; sets of different diameters are furnished, arranged to screw into a common insulated stem. Currents of from five to twenty milli-

amperes are used, the length of the treatment varying with the condition. The acid ions unite with the metal of the anode, forming oxychlorides of zinc or copper, which are driven into the mucous membrane surrounding the electrode. As this action causes *adhesion,* it will be necessary after turning off the current, to turn it on again in the *opposite direction,* after which the electrode may be readily withdrawn.

14. *Negative electrolysis* is a destructive process in which redundant or diseased tissues are softened and disintegrated by the chemical action of "caustic soda," which collects

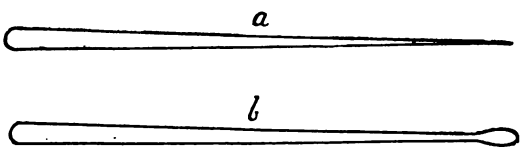


FIG. 36.—*a,* Sharp-pointed needle ("Broach") for moles and warts *b,* Bulb-tipped needle for removal of hair.

around the negative electrode as a result of the electrical decomposition of the sodium chloride in the tissues of the body. If a galvanic current be passed through a solution of a salt, such as sodium chloride, the chlorine, or negative ions of the latter, will collect around the positive electrode, while the sodium or positive ions appear at the cathode. A chemical reaction will then occur in which an atom of sodium takes the place of an atom of hydrogen in a molecule of water; the result being sodium hydroxide, which dissolves in the solution and hydrogen gas which bubbles to the surface. If potassium iodide be used, the iodine, which is liberated at the positive pole, appears as a *dark brown cloud.* This reaction forms a convenient test for polarity; for example:—if we wish to determine the poles of the Edison electric lighting current, the two tips of the conducting wires

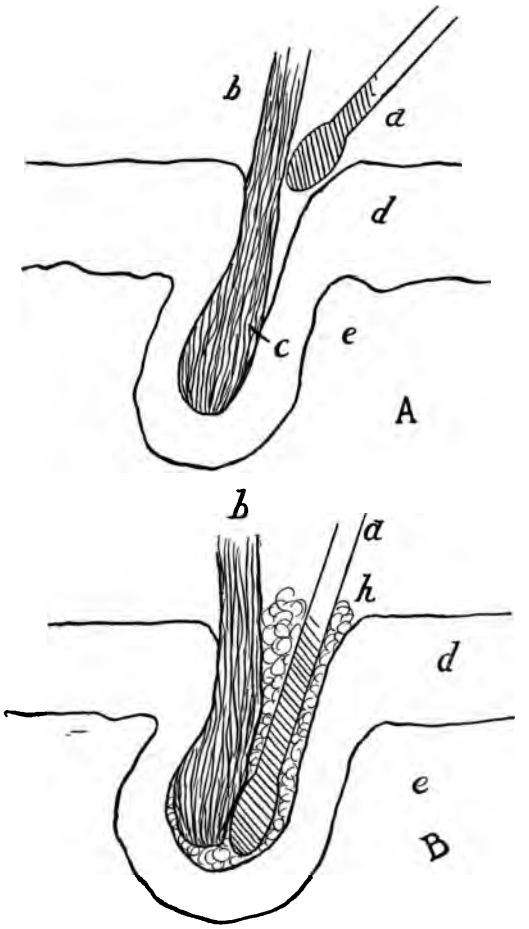


FIG. 37.—ELECTROLYSIS OF HAIR FOLLICLE; MAGNIFIED 600 DIAMETERS.

A. Bulb-tipped needle, (*a*) working its way into the follicle, (*b*) containing the hair-root, (*c*).

B. Needle, (*a*) in the follicle, which is being converted into a soap-like débris, (*b*) mixed with Hydrogen bubbles. *d*, Epidermis. *e*, Dermis, or true skin.

are touched to the opposite sides of a drop of potassium iodide solution, and the positive terminal at once surrounds itself with a *brown cloud,* while fine white bubbles rise from the negative wire. The tissues of the human body are rich in sodium chloride, which also forms 0.6 per cent. of the blood-serum and lymph. When a galvanic current passes through the body, the sodium hydroxide, or caustic soda, which collects at the negative electrode, will destroy the

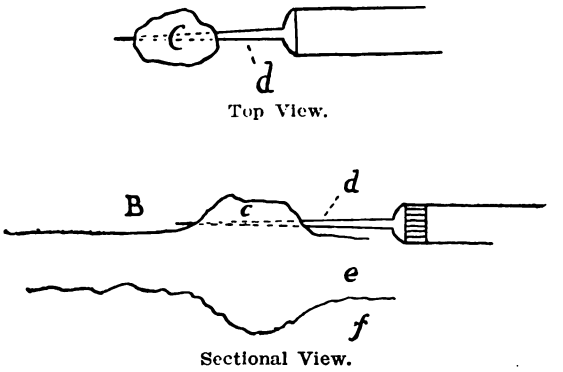


FIG. 38.—ELECTROLYSIS OF A WART OR MOLE.

c, Portion of the growth raised above the surface of skin.
d, Sharp needle in holder, piercing the growth.
e, Epidermis. *f,* True skin.

tissues in immediate contact with the latter, converting them into a soap-like material.

When this process is applied for the removal of superfluous hair, the cathode should consist of a fine steel needle having a rounded, bulb-like extremity and fixed in an insulated holder. Some operators prefer to use a sharp pointed needle or jeweler's broach. This requires more skilful handling but admits of more rapid work. The needle should be carefully slipped into the follicle at the side of

the hair which is to be removed, using a magnifying glass if necessary. The patient is then instructed to gradually bring the right hand into contact with a sponge-covered electrode, or to gradually immerse the fingers in a bowl of salt solution, which contains the positive electrode. From

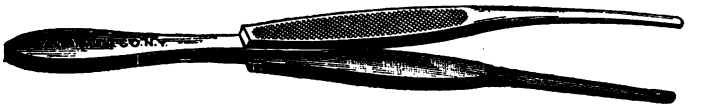


FIG. 39.—EPILATION FORCEPS.

one to two milliamperes should be used, until a white bubble, the size of a pin head, appears at the mouth of the hair follicle; the patient is then instructed to break contact, or to slowly withdraw the fingers from the solution; the needle is then removed, and if the operation has been successful, the hair may be slid from the follicle by means of a pair of forceps. If the hair resists, it should not be pulled out, as the follicle has been only partially destroyed. The

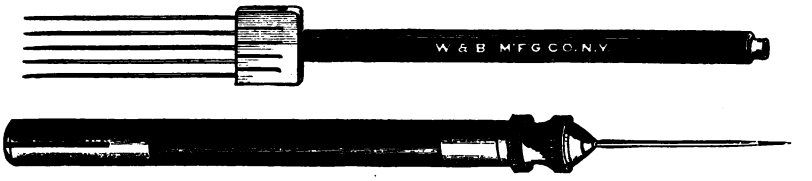


FIG. 40.—NEEDLE HOLDERS FOR ELECTROLYSIS OF BIRTHMARKS, HEMORRHOIDS, ETC.

needle should be again inserted and the current passed until the hair is completely loosened from its attachments. From one-half to two minutes will be required for the destruction of each hair, according to its size and the character of the follicle. It is unwise to remove all the hairs from a small area at one sitting. It is safer to remove a few hairs from

each affected area. The writer prefers to connect the patient permanently to the positive pole during the entire sitting, the circuit being formed and broken by the insertion and withdrawal of the needle.

For the removal of warts, moles, birthmarks, etc., practically the same technique is employed as in the destruction of superfluous hair, except that sharp-pointed needles are always used. The point of the needle is inserted in the growth near its base and pressed in until it almost emerges from the opposite side; the needle will then be almost parallel with the surface of the skin. A sponge-covered electrode, wet with salt solution, is held in the hand of the

FIG. 41.—SET OF OLIVE TIPS FOR URETHRAL STRICTURE ARRANGED TO SCREW ON AN INSULATED STEM.

patient, and a current of from two to fifteen milliamperes is gradually turned on. For small growths not more than a quarter of an inch in diameter, not more than five milliamperes will be required. The current is allowed to flow until the entire growth acquires a white bleached appearance. This will be accomplished in from one-half to two minutes in the majority of cases. If the growth be larger than the average, it may be necessary to repeat the operation, the needle being inserted at right angles to its first position. The application of antiseptics, cerates, etc., should be avoided, as the growth usually shrivels into a brown scab, which falls off in the course of a week or two. Spirit of camphor applied after the operation will hasten the drying process. For the destruction of birthmarks covering a considerable surface, an electrode is used consisting of from

three to six needles fixed in a clamp, forming a row of points about one-eighth inch apart. These are inserted to the depth of about one-eighth inch, and the current turned on until the bleached area is formed around the row of points. The latter are then inserted parallel to their first position

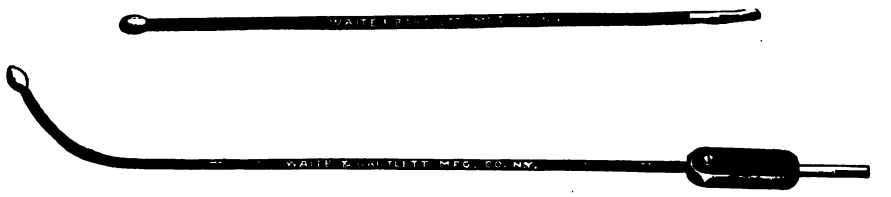


FIG. 42.—STRAIGHT AND CURVED OLIVE-TIPPED ELECTRODES FOR ELECTROLYSIS OF STRICTURE OF URETHRA.

at such a distance that the second bleached area will just meet the edge of the first. This process is continued until the entire area of the birthmark has been bleached. It is hardly necessary to state that the current should be gradually shut off after each operation before removing the needle.

FIG. 43.—CHANNEL ELECTRODE WITH FILIFORM DIRECTOR, FOR AGGRAVATED CASES OF STRICTURE IN WHICH POCKETS HAVE FORMED IN THE URETHRA.

In the treatment of *urethral stricture* by negative electrolysis, the method devised by the late Dr. Newman, small olive-shaped metal cathodes are employed, graduated and numbered according to their diameter, as in the case with urethral sounds. They are sold in sets and arranged to screw on to the end of a slender insulated stem, which may

be straight, curved or flexible. It is safer, although more expensive, to employ instead of the above outfit a set of olives, each of which is permanently fixed to a separate insulated stem. A urethral stricture is a circular scar or cicatricial ring formed of dense fibrous connective-tissues, without capillaries of lymphatics, which partially occludes the lumen of some portion of the urethra. The internal diameter of the stricture should first be ascertained by the

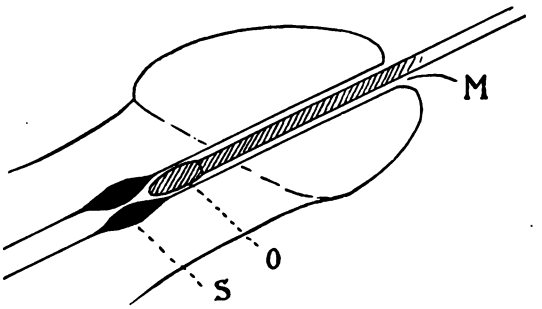


FIG. 44.—METHOD OF APPLYING ELECTRODE IN ELECTROLYSIS OF STRICTURE. (Shown in section.)

M, Meatus Urinarius. *O*, Olive Tip of Electrode. *S*, Cicatricial Ring, which Constitutes the Stricture.

passage of sounds, great care being taken to avoid forcible dilatation. An olive-tipped cathode, several sizes larger than the lumen of the stricture, is carefully passed into the urethra until its anterior portion is in contact with the fibrous ring. A large flat anode, wet with salt solution, is placed over the abdomen and the current gradually turned on, while the cathode is gently pressed against the stricture. In from five to ten minutes the latter will have been softened so as to permit the olive tip to pass completely through. On attempting to withdraw the cathode, resistance will again be encountered, and it should be held against the under side

of the stricture until the current renders its removal easy. With small olives not more than five milliamperes should be used, while with medium or large olives a maximum of ten or fifteen milliamperes, respectively, may be employed. When the patient complains of pain or burning, it is an indication that too strong a current is being used. Treatments should be given not oftener than once a week. At the first treatment only one size of cathode is to be used. At the second treatment it will be found necessary to repeat the original procedure with the olive first employed, after which the operation is repeated with a cathode of a slightly

FIG. 45.—ELECTRODE FOR TREATING ENLARGED PROSTATE, PER RECTUM.

larger size. The reason for this procedure is that the fibrous ring slightly contracts during the interval between treatments, thereby reducing the lumen of the stricture. The treatments should be continued until the fibrous ring is practically obliterated, or until its lumen remains of the same diameter as other portions of the urethra. If carefully followed, a permanent cure will be obtained in almost every case. Where the stricture is complicated by a chronic gleet, or cystitis, it will be necessary to employ very mild currents and avoid forcible dilatation. Many so-called failures result from the neglect of these precautions, as the slightest force on a chronically inflamed urethra will tear the mucous membrane, forming an ulcer, which will, in turn, lead to the formation of another stricture.

Stricture should never be treated electrolytically when acute inflammation is present; in these cases, treatment with glass vacuum electrode in the urethra and Tesla high-frequency current will often destroy the infection and cause the inflammation to subside, after which the stricture may be treated in the above described manner. Failure with the Newman method is almost always due to improper tech-

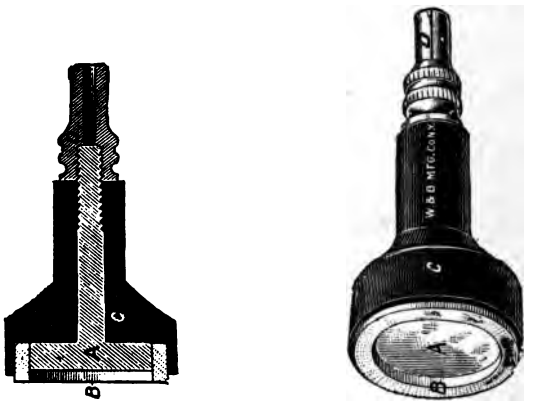


FIG. 46.—RESERVOIR ELECTRODE FOR CATAPHORESIS.

nique or the use of too strong currents. The rule in these cases is to "Make haste slowly."

Negative electrolysis is also employed in the treatment of uterine fibroid, hemorrhoids, etc. For the special technique used in these different conditions, the reader is referred to the chapter on Special Therapeutics.

15. *Cataphoresis, electrical osmosis* and *Ionization* are more or less synonymous terms applied to the process of driving medicinal substances into the tissues by means of galvanism. The action results from the attraction and repulsion of *Ions* under the influence of a constant current; substances being characterized as *electro-positive* and *electro-*

negative, according to their action in reference to the poles of a galvanic circuit. Generally speaking, all metal or basic substances are electro-positive; acids, on the other hand, are electro-negative. If we employ a solution of salt such as *iodid of lithium,* for example, we may drive either the *iodin* or the *lithium* into the tissues. If a sponge-covered electrode be soaked in a solution of the salt, and connected to the *positive pole* of a galvanic battery, the *lithium ions* will be driven into the tissues; while if the electrode is attached to the *negative pole,* the *iodin* will be driven in. By bearing

FIG. 47.—ELECTRIC METRONOME OR RHEOTOME FOR MECHANICALLY INTERRUPTING A CURRENT.

in mind the polarity of the different chemical substances and observing the law that "bodies of like polarity mutually repel," while "those of unlike polarity mutually attract," the physician will have no trouble in determining the particular pole which should be used to drive a given substance into the body.

Ionization, or electrical osmosis, is commonly employed—with a solution of *cocain* to produce *local anesthesia*—with *adrenalin,* to drive the blood from the capillaries prior to operation or application of the ultra-violet ray; with salts of *lithium,* or *salicylic acid,* in the treatment of gout; with *iodin,* or its salts, in the treatment of goitre and syphilitic lesions; with *chloroform,* or *tincture of aconite,* in facial

neuralgia; and with *metallic mercury* for the destruction of malignant tumors, according to the method of Doctor Massey. (See chapter on "Dental Electro Therapeutics.")

16. *Interrupted galvanism,* or the use of the constant current mechanically interrupted, or broken into a series of periodic impulses, is closely allied to the primary current from a faradic coil. (See chapter on "Electro-diagnosis" and that on "Special Therapeutics.")

CHAPTER V

FARADISM

1. ***Faradism,*** as stated in a previous chapter, is a term applied to the interrupted current obtained from the secondary circuit of an induction coil. Electrically speaking, it is an ***induced, unsymmetrical, alternating, interrupted current,*** of ***relatively high voltage*** and ***low amperage;*** the potential varying from 1,000 to 50,000 volts, and the volume from one one-thousandth to one milliampere, according to the size and length of the secondary coil and the strength of the current in the primary.

2. The faradic coil has been more generally employed in

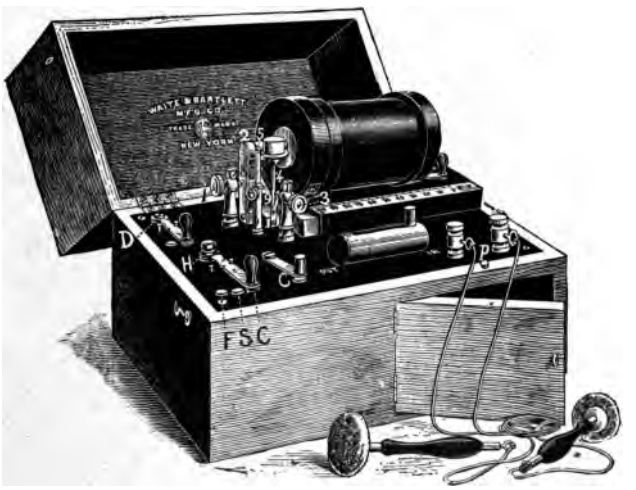


FIG. 48—HIGH TENSION FARADIC APPARATUS.

therapeutics than any other electrical apparatus. This is largely due to its simplicity, cheapness and portability. There is no doubt but that its indiscriminate use by charlatans and ignorant practitioners has had much to do with the general skepticism regarding the therapeutic value of electricity which is still prevalent among the less progressive members of the medical profession.

3. The sensation produced by the faradic current is no doubt of value for its suggestive or psychic effect, and it

FIG. 49.—HIGH AND LOW TENSION FARADIC APPARATUS.

may be legitimately employed for this purpose in treating cases of an hysterical or hypochondriacal nature. Bernheim, the great authority on psycho-therapeutics, obtained remarkable results by the use of the faradic current as an accessory to treatment by suggestion.

4. A good faradic outfit should consist of a soft-iron core, wound with several layers of medium-sized wire, so arranged as to permit the use of two or more secondary coils, which

are slipped over the primary to a greater or less degree, according to the strength desired. One of these secondaries should consist of a comparatively small number of turns of relatively coarse wire. Another should have a very large number of turns of fine wire. The outfit should be provided with both a slow and a rapid interrupter, the latter being preferably of the "ribbon" type, consisting of a thin strip of steel stretched between two posts, one of which is provided with a screw for adjusting the tension. The

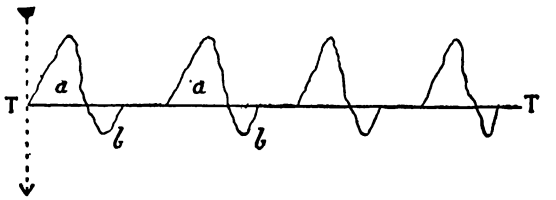


FIG. 50.—CURVE, OR GRAPHIC TRACING OF A FARADIC CURRENT. *a a*, The impulses induced by the Primary "Break." *b b*, The impulses induced by the Primary "Make." *T T*, Abscissa, or Time Line. *V V*, Ordinate, or Voltage Line.

coarse or slow interrupter should be adjustable so as to give a range of two to ten breaks per second, while the rapid interrupter should give from 100 to 5,000 breaks per second.

5. The term *"unsymmetrical," "alternating,"* and *"interrupted"* have been applied to the faradic current:

It is *"interrupted"* because the different impulses are separated by intervals, during which no current passes.

It is *"alternating"* because the impulse induced when the core becomes magnetic is in opposite direction to the impulse induced when the core loses its magnetism.

It is *"unsymmetrical"* because the impulse produced by the closure, or "make," is less than the impulse which follows the "break," or opening, of the primary circuit.

6. Large induction coils of the *Ruhmkorff* type consume a considerable volume of current in the primary circuit, and are usually excited by storage batteries, or the continuous electric light current. The latter may also be used for the operation of faradic coils by placing a 16 candle-power incandescent lamp bulb in series with the primary coil and interruptor.

It is usually more convenient to employ the ordinary dry-cell batteries, two to four of which are sufficient for the operation of an ordinary faradic coil.

7. The physiological effect of a faradic current depends largely upon its voltage and frequency of interruptions. A current of low voltage and slow interruption acts principally on the muscles and the motor nerves, producing intermittent or *clonic* muscular contractions; while a current of the same voltage, but of higher frequency, produces a continuous contraction, technically known as a state of *tetanus,* or *tonic spasm.*

A faradic current from a high-tension secondary should be of a high-frequency, such as is produced when the ribbon vibrator emits a musical note. A current of this character is of great value in the treatment of neuralgia, and other forms of acute pain, except those associated with inflammation or septic infection. The low-tension faradic with slow interruption is used therapeutically to promote muscular growth, to relieve stiffness due to rheumatism, or following an injury, to promote the absorption of exudates, gouty deposits, etc., and for the production of muscular contractions, as a form of passive exercise, in case of partial paralysis, muscular atrophy, etc.

8. Judged by its actual physiological effects, there is no doubt but that faradism is the least important of the various currents used in electro-therapeutics. In office practice, the low-tension faradic is now practically superseded by the

interrupted galvanic and the sinusoidal current, while the Tesla high-frequency current with vacuum electrodes has almost displaced the rapid high-tension faradic current in the treatment of local pain. The faradic current has still a valuable, though limited, field, especially for the general practitioner and for bedside use in suitable cases.

CHAPTER VI

ELECTRO-DIAGNOSIS

1. The manner in which muscles react to electrical impulses in a healthy organism differs from the reaction of diseased or degenerating muscles and nerves. *Electro-diagnosis* is based upon the above proposition.

2. In testing for degeneration in nerves or muscles, a small

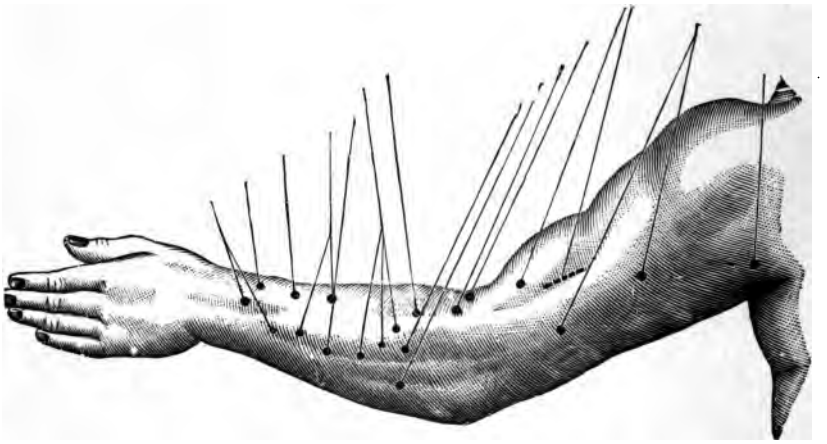


FIG. 51.—MOTOR POINTS.

sponge-covered electrode is used, which is applied to certain areas called *motor points,* each of which corresponds to a particular nerve and muscle. A large, indifferent electrode is usually applied to the abdomen. A slowly interrupted galvanic current and a moderately rapid faradic current of medium tension are used in making the tests.

3. Muscular atrophy usually follows lesions or injuries to the nerve centers in the anterior horns of the spinal cord; it occurs in acute Anterior Poliomyelitis ("Infantile Paralysis"), Lateral Sclerosis, Spinal Abscess, etc. As degeneration is almost invariably *unilateral,* it is customary to test corresponding muscles alternately on the right and left side, as in this way the difference in reaction between a normal and a degenerated nerve center is readily demonstrated.

4. When the cathode is applied to the motor point of a healthy nerve or muscle, and a slowly-interrupted galvanic

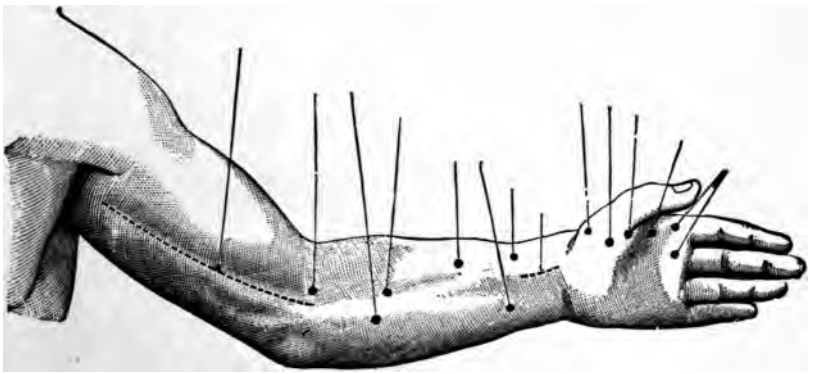


FIG. 52.—MOTOR POINTS.

current is gradually turned on, a point will be reached at which the muscle will *contract* at each *closure* of the *circuit.* This is called the *"Cathode-closure contraction."* If the polarity of the electrodes be now reversed, it will be found necessary to increase the strength of the current before the muscle will contract—as in the first instance—at each closure of the circuit. This second contraction is called the *"Anode-closure contraction."* If the current be again increased, we obtain a contraction at each *"break"* as well as at each *closure* of the circuit; in other words, an *"Anode-opening*

contraction." To produce a *"Cathode-opening contraction"* in a normal muscle requires a stronger current than most patients can bear.

5. In well-marked degeneration of a nerve the above order is *reversed,* the *Anode-closure contraction* being manifested by a *weaker current* than that necessary for the production of a contraction at *Cathode-closure.* In extreme or complete degeneration, the contraction either does not occur at all, or follows sluggishly and with an interval between the *Anode-*

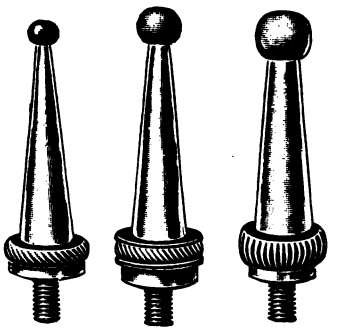


FIG. 53.—MOTOR POINT ELECTRODES FOR ELECTRO-DIAGNOSIS.

closure and the *muscular impulse.* In many conditions which involve nerve degeneration, the muscle does not contract under the influence of the *faradic current.* In less severe conditions, the contraction requires a strong current and occurs only after an appreciable interval. For the differential electrical diagnosis of the various forms of degeneration, the reader is referred to the standard text-books on nervous diseases.

CHAPTER VII

STATIC ELECTRICITY

1. So-called *"Static" electricity* is usually derived through electrical induction between revolving glass plates and charged areas fixed to stationary glass plates. The *"Holtz*

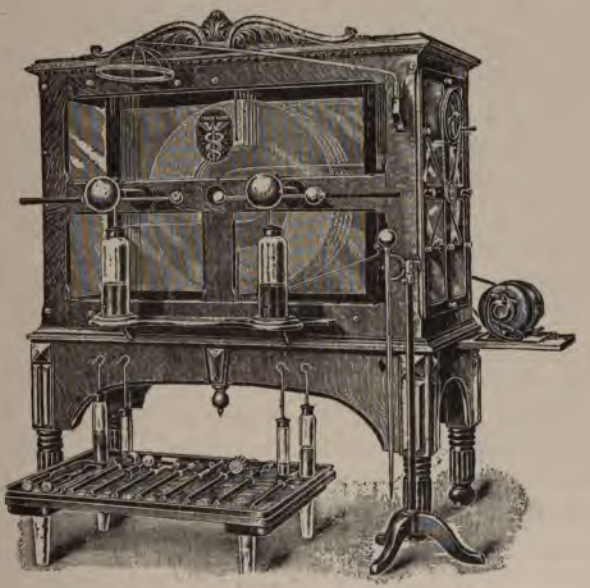


FIG. 54.—MODERN STATIC MACHINE.

machine" exemplifies this principle and is the most popular form of static apparatus among American physicians. In Europe, the *"Wimshurst machine"* is more generally em-

ployed. It generates its currents through the mutual induction of parallel glass or rubber plates revolving in opposite directions. Its initial charge is obtained by the friction of small tinsel brushes against the revolving plates. It possesses certain advantages over the Holtz machine, in that it is less sensitive to moisture and is self-charging, while the Holtz machine must be given an initial charge before it can generate a current. This is usually accomplished by the use of a small Wimshurst machine, mounted in the end of the case containing the large apparatus. A number of Western manufacturers have introduced static machines of the so-called *"Toepler-Holtz"* type. They differ from Holtz machines in that they are self-charging, by the use of tinsel brushes, as in the "Wimshurst."

2. The charge from a static machine is *unidirectional,* of *great voltage* and *extremely small amperage.* In therapeutic machines the current will average between 10,000 and 100,000 volts, and the volume from one one-thousandth to two milliamperes (1/1000 ma. to 2 ma.). The greater the number of revolving plates, the greater will be the amperage. The greater the diameter of the plates, the greater will be the voltage.

3. The *static discharge* between the metal balls which form the terminals of most machines appears as a zigzag spark, with the thicker, brighter portion next to the *positive terminal.* It appears, and is in reality, a perfect miniature reproduction of a flash of lightning. If the terminals be too far apart for the spark discharge, the current will still appear as a violet brush discharge called an *"effluve."* If the terminals be still further separated, no actual current will pass between them, but the electricity will discharge into the air from the positive pole in the form of a purple brush, or *"aigrette,"* and at the negative pole in the form of a number of brilliant points. If the terminals be approached within

sparking distance, and a metal ball-tipped electrode, connected with the ground, be brought near the positive pole, the spark will be diverted to the earth and cease to flow between the terminals; but if the electrode be brought near the negative terminal, the spark will continue to flow between the poles. The static discharge tends to the form of sparks between spherical surfaces, and forms an *"effluve"* between metal points or sharp edges.

If a *Leyden* jar be attached to each terminal of a static machine, and the two outer coatings be connected by a rod or wire, the spark between the terminals will be made *longer, brighter, louder* and *less frequent.* Increasing the size of the Leyden jar increases the degree of each of the above qualifications.

4. For the therapeutic administration of static electricity, a large platform should be provided, supported by insulating glass legs not less than six inches high. The patient either sits in a chair upon the platform or stands upon a metal plate placed upon the platform and connected to one pole of the static machine by a rod or chain. When sitting in a chair the metal rod or chain is held in the patient's hand. Various electrodes should be provided, including a small and large metal ball, and a single and a multiple metal point electrode, each being provided with an insulating handle of wood or hard rubber. A metal roller electrode is also desirable; also four metal disk electrodes, two of which should be sponge- or felt-covered, like those used in faradism. An uninsulated metal point electrode, and a wire *"fly brush"* with an insulated handle, are desirable. Various forms of *"vacuum electrodes"* are employed with the static machine, but they are usually restricted to the application of high-frequency currents.

5. Static electricity is applied in therapeutics in a number of distinct modifications, or *"modalities,"* as follows:

(a) *"Static insulation,"* or the *"Static bath."*
(b) The *"Static breeze."*
(c) The *"Static effluve,"* or *"Brush discharge."*
(d) Direct or indirect *"Static sparks."*
(e) The *"Static induced currents."*
(f) The *"Morton wave current."*

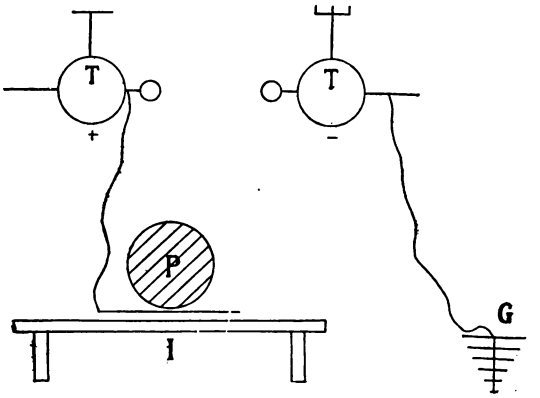


FIG. 55.—STATIC INSULATION.

T T, Terminals of Static Machine. *I,* Insulating Platform. *P,* Patient. *G,* Ground Connection.

6. The *Static bath* is spoken of as *positive* and *negative electrification,* according to the polarity of the terminal to which the patient is connected. The latter sits in a chair on the platform, being connected to one terminal of the machine by the metal rod or foot-plate, and the opposite terminal is connected to the earth by means of a wire attached to a water- or steam-pipe. A soothing, restful effect is produced on the patient, especially if he be connected to the positive pole. This method is of value in the treatment of insomnia, hysteria and reflex nervous conditions.

7. *Static breeze* is administered by the use of a metal or carbon-point electrode, suspended over the patient's head or held about a foot away from any part of the body which it is desired to treat. The electrode is connected to the positive pole, which is grounded. The patient is seated on the platform and connected with the negative pole. This modality is of service in the treatment of headache, local congestion of nervous origin, and in neuroses. By reversing the poles with the above arrangement a negative static breeze

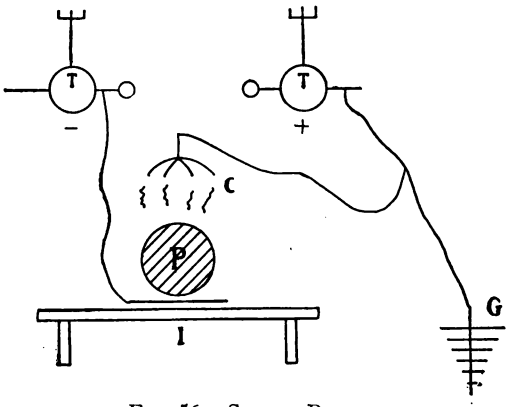


FIG. 56.—STATIC BREEZE.
C, "Canopy," or "Umbrella" Electrode.

is obtained, but the first method is preferred as it causes less irritation.

8. The *Static "effluve," or "brush discharge,"* is obtained by the method just described, except that the pointed electrode is held at a shorter distance from the body. The effects are more intensely stimulating than with the breeze, and the method is employed for the relief of a variety of conditions, such as rheumatism, neuralgia, spinal irritation, and local congestion of a superficial nature.

9. The *Static spark* is usually applied indirectly, by means of an insulated metal ball electrode, attached to which is a chain with its opposite end in contact with the floor. The patient is connected as for *"positive electrification,"* and the sparks applied through the clothing by carefully approaching the affected area with the electrode. A sharp muscular contraction is produced by each spark, especially when it is applied to a motor point. Sparks may be rendered less painful by holding a small metal ball electrode in contact

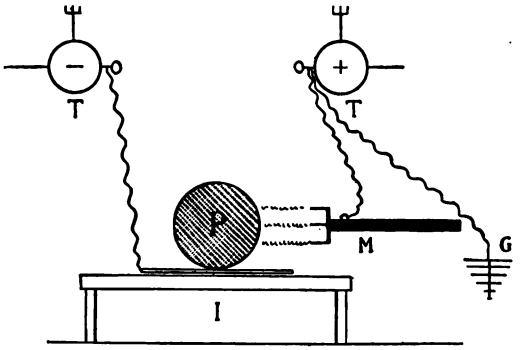


FIG. 57.—STATIC "EFFLUVE," OR "BRUSH DISCHARGE."
M, Metal Point Electrode.

with the skin over the affected area, and allowing the spark to pass between this electrode and the one which is connected to the floor by the chain. The direct spark is applied by means of an electrode connected to one terminal of the machine, no connection being made with the other terminal and the patient in an ordinary, uninsulated chair. The latter method is not recommended, but is sometimes employed in the treatment of motor and sensory paralysis. Indirect sparks are used in the treatment of muscular rheumatism, partial paralysis, spinal disease, acute neuralgic pain, and constipation resulting from muscular atony.

10. The *Static induced current* was introduced by Dr. W. J. Morton in 1881. It is applied to the surface of the body by means of two wet sponge-covered electrodes, connected respectively to the outer coatings of two Leyden jars, each of which is attached to a terminal of the static machine.

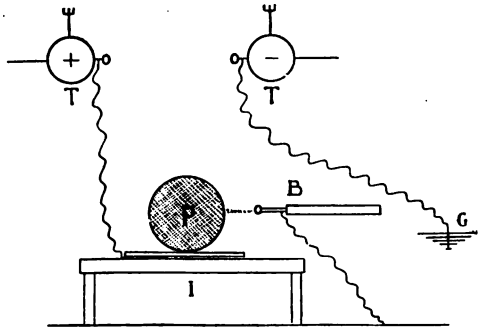


FIG. 58.—STATIC SPARK. (INDIRECT.)
B, Metal Ball Electrode.

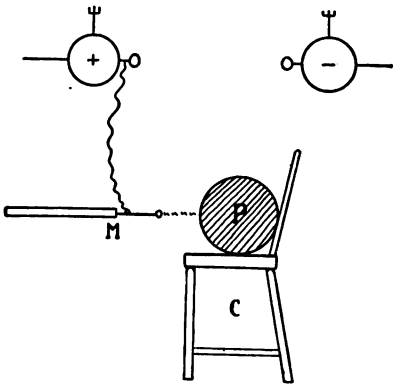


FIG. 59.—STATIC SPARK. (DIRECT.)
M, Small Metal Ball Electrode. *C*, Uninsulated Chair for Patient.

In the static modalities thus far considered, the sliding terminal rods are *withdrawn* so that no discharge can pass between them. In the static induced current the machine is started with the two sliding rods in *contact,* and they are then *gradually separated* until the patient complains that the current is unpleasantly strong. In a few moments a toleration will be established, so that the current can be borne

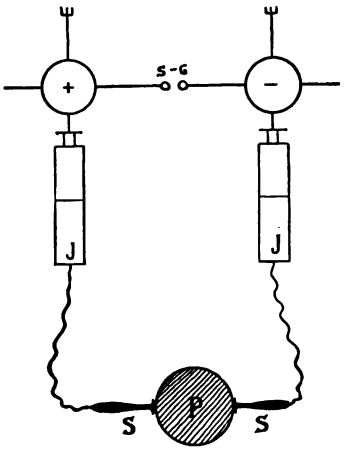


FIG. 60.—MORTON STATIC INDUCED CURRENT.
S G, Spark Gap. *J J,* Leyden, Jars. *S S,* Sponge Electrodes. *P,* Patient.

without discomfort. This modality may be used as a substitute for the Faradic current, the low-tension effects being obtained by the use of large Leyden jars, while small jars produce a current similar to that from a high-frequency secondary coil. It is used in the treatment of the same conditions that would be benefited by faradism, and is also of value in relieving stasis and stimulating sluggish metabolism.

11. The *Morton wave current* was first described by its inventor in 1899, and is without doubt the most important

of all static modalities. The negative terminal is ***grounded,*** and a metal disk electrode, connected to the positive terminal, is placed in contact with the affected area of the patient's body. The patient sits or stands on the insulated platform and the current is administered by gradually separating the terminals, which should be in contact when the machine is started, the same as with the static induced current. If desired, a second metal electrode, connected to an insulated object—such as a metal tube stand—may be applied to some indifferent portion of the body. Generally

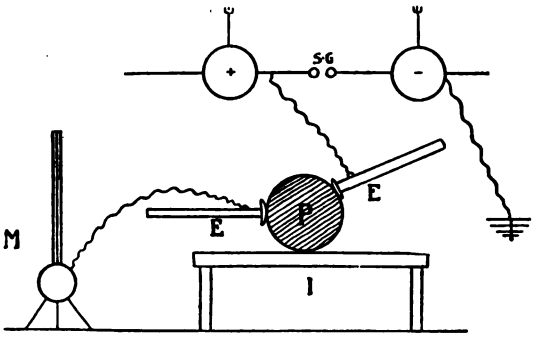


FIG. 61.—MORTON WAVE CURRENT.

S G, Spark Gap. *E E,* Sponge Electrodes. *M,* Metal Stand. *P,* Patient.

speaking, the current increases metabolism, promotes tissue drainage, and stimulates the circulation and the secretions. It is indicated locally for the relief of pain, for the increase of muscular growth and activity, and for the dispersion of congestion, inflammatory exudates, and gouty and rheumatic deposits. It is ***contra-indicated*** in acute septic conditions, involving local congestion and pus-formation. In common with all other static and faradic modalities, it should be ***avoided*** in the treatment of organic heart disease.

CHAPTER VIII

HIGH-FREQUENCY CURRENTS

1. About the year 1890 Professor d'Arsonval, of Paris, conducted a series of experiments with alternating currents of different frequencies. He employed a mechanical alternator consisting of a revolving drum carrying a number of electro-magnets on its periphery, rotating inside of a ring of laminated iron, having a number of internal projections corresponding to the number of electro-magnets on the drum. A series of coils wound upon the iron projections were excited by a direct current from a battery or dynamo, and by revolving the drum at different speeds, sinusoidal alternating currents of different frequencies were induced in the revolving coil.

2. With an apparatus of this description d'Arsonval made a number of tests to determine the relation of frequency to sensory and motor nerve reaction. He found that a current alternating less than fifteen times per second produced a succession of separate, or "clonic" muscular contractions. A frequency of from 20 to 30 per second produced a continuous contraction; in other words, a "tetanus" or "tonic spasm." Increasing the frequency beyond this point increases the intensity of the tetanus. At about 300 alternations per second the maximum intensity is reached, and a further increase of frequency causes a decrease in the strength of the contractions, until at a frequency of 10,000 per second absolutely no effect is produced upon either the motor or the sensory nerves.

3. A current, therefore, which alternates or oscillates

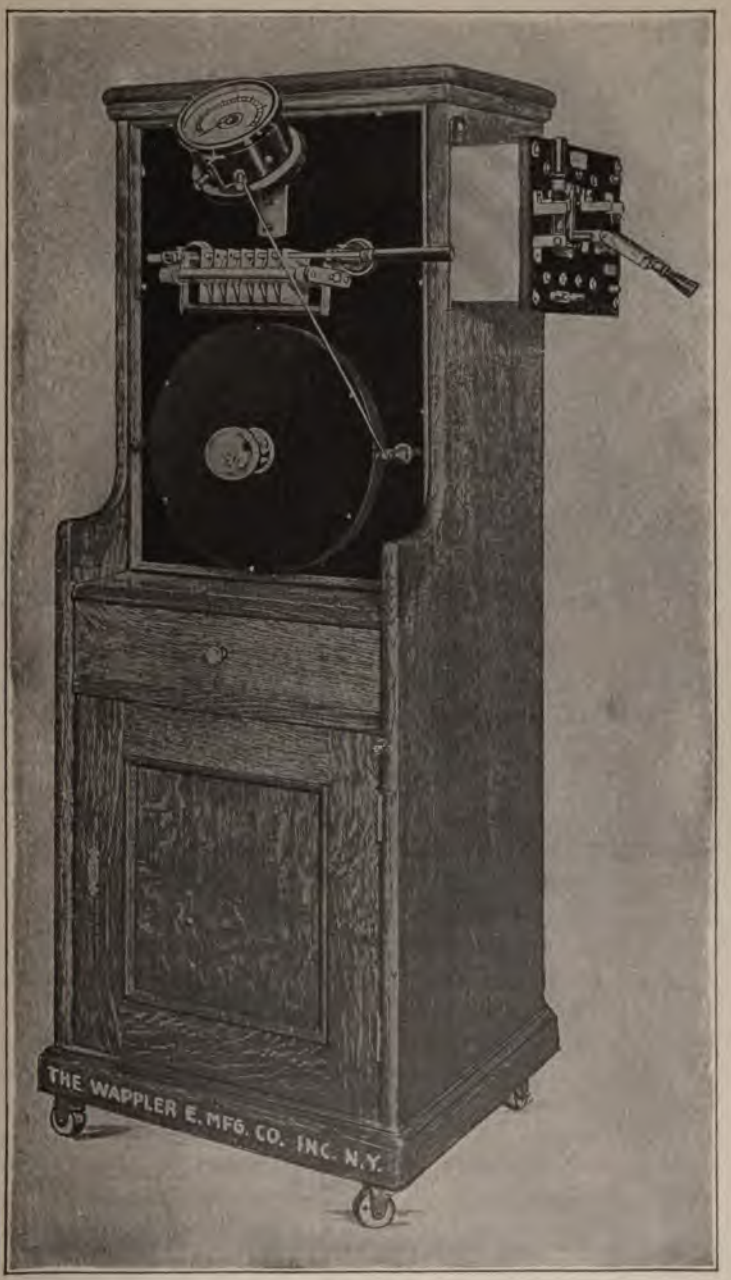


FIG. 62.—WAPPLER EXCELL HIGH-FREQUENCY APPARATUS.

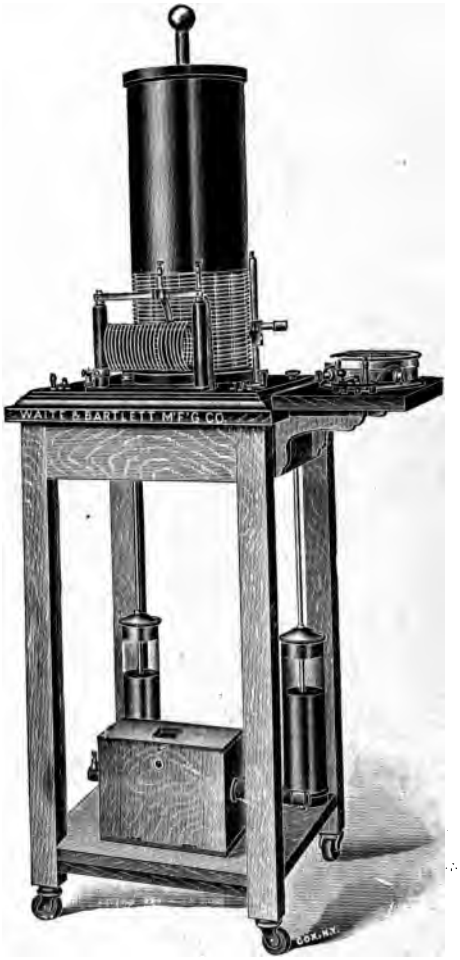


FIG. 63.—RESONATOR AND SOLENOID.

10,000 or more times per second is called, from a physiological standpoint, a *"High-frequency current."* The high-frequency currents used in therapeutics are oscillating much more rapidly than this, varying in frequency from 500,000 to 5,000,000 alternations per second. The writer has experimented with coils of different frequencies between these limits and believes that for Tesla apparatus the best results are obtained with frequencies about 1,000,000 per second;

FIG. 64a.—SMALL HIGH-FREQUENCY COILS FOR ALTERNATING OR DIRECT CURRENT.

for auto-condensation, 3,000,000 per second, and for diathermy, about 2,000,000 per second.

4. At the present time three types of high-frequency apparatus are employed in therapeutics, namely:

FIG. 64b.—PORTABLE HIGH-FREQUENCY APPARATUS WITH INTERCHANGEABLE SECONDARY WINDINGS.

(a) The *"Solenoid currents"* of d'Arsonval, introduced to the profession in 1893.
(b) The *"Resonator discharge,"* developed by Oudin and presented to the profession about 1896.
(c) The *"Tesla-Thompson currents,"* first employed therapeutically by the present writer in 1896.

5. Among European physicians, the d'Arsonval and Oudin currents are principally employed, being obtained from an apparatus consisting of a resonator combined with a d'Arson-

val solenoid, an adjustable *spark-gap* and a pair of *condensers* of the *Leyden-jar* type. This apparatus is usually excited by the secondary current from a Ruhmkorff X-ray coil, but a static machine may be employed provided it has

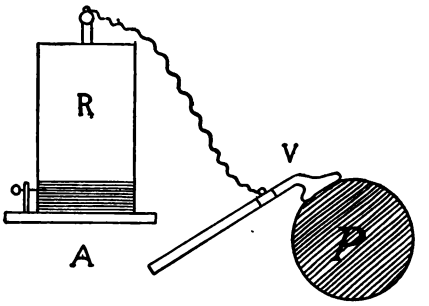


FIG. 65.—*A*, Direct Application of Resonator Discharge with Vacuum Electrode.

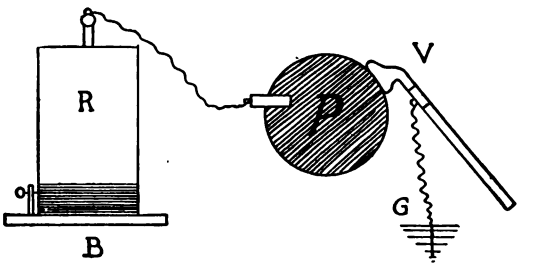


FIG. 66.—*B*, Indirect Application with Metal Hand Electrode and Vacuum Electrode.

a sufficiently large number of revolving plates to furnish the required amperage.

6. The current from the *Oudin resonator,* which is unipolar, of high voltage and high-frequency, is applied to the patient by means of a rubber-covered wire, connecting the terminal of the resonator to a glass or metal electrode, pro-

vided with an insulating handle; or the patient may be connected directly to the wire from the resonator, by a metal hand-electrode, and the current *drawn off* from some other portion of the body by means of a *grounded electrode,* applied by the operator. To obtain the maximum effect in the latter case, the apparatus should be "tuned" in accordance with the capacity of the patient's body by cutting out one or more turns of the solenoid coil. This is accomplished in a number of ways.

7. The current derived from a d'Arsonval solenoid is *bi-polar,* of *high-frequency,* of relatively *high amperage* and

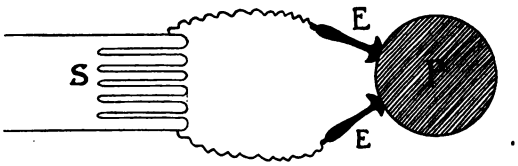


FIG. 67a.—DIRECT APPLICATION OF D'ARSONVAL SOLENOID CURRENT ("Diathermy").

S, Solenoid. *E E,* Electrodes. *P,* Patient.

moderately *high voltage.* It is employed therapeutically in two ways:

(a) *Direct application,* or *"Diathermy";* this is a recently developed modality and has proved of great value in the treatment of local conditions in which it is desirable to liberate heat in the tissues or to set up an artificial aseptic inflammation. It produces an active hyperæmia in the tissues traversed by the current, and is therefore of great value in chronic infections accompanied by anæmic areas, as in tuberculosis. Most modern high-frequency outfits have a special current adapted for

diathermy. The current is passed directly through the tissues, to be treated by means of flat metal electrodes. These are usually of block tin and can be bent to the shape of the surface to which

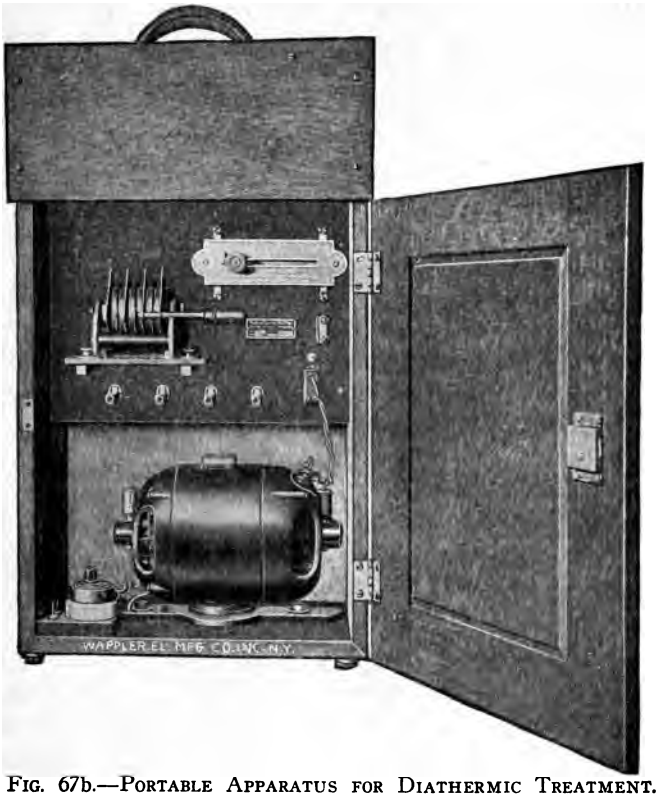


FIG. 67b.—PORTABLE APPARATUS FOR DIATHERMIC TREATMENT.

they are applied; they should be held in firm contact with the skin either by bandages or by being weighted by sand bags. For ordinary diathermic treatments, electrodes averaging 2 x 4 in.

are used; some authorities advise covering the electrodes with wet gauze, as with the constant current (galvanism); it is much safer to use the uncovered metal, however, as bad burns may result from the first method owing to the evaporation of the liquid by the intense heat of the current.

Diathermic treatment may be used to destroy redundant tissues by actually *cooking* it in situ. This method is properly a branch of electro-surgery; to distinguish it from therapeutic diathermy it should be called "electro-coagulation"; for this purpose a small metal electrode is used in contact with the tissue to be destroyed, and an ordinary diathermic electrode placed on the spine at an adjacent area. For therapeutic purposes, from 1,000 to 2,000 milliamperes are usually employed for from 10 to 20 minutes. In electro-coagulation—which is usually done under anæsthesia—sufficient current is used to bleach the treated tissues to a light gray color. The ideal current for diathermy has a potential of from 1,000 to 10,000 volts, an available intensity of from 1,000 to 2,500 milliamperes, and a frequency approximating 2,000,000 alternations per second.

(b) *Indirect methods,* including *Auto-conduction* (I) and *Auto-condensation* (II).

(I) "Auto-conduction" is seldom used in this country, as the condenser couch produces practically the same results. In the application of high-frequency currents by auto-conduction, a large wire spiral, wound in the form of a vertical or horizontal cage, is connected to the outer coatings of two Leyden jars in place of the small solenoid, the patient stand-

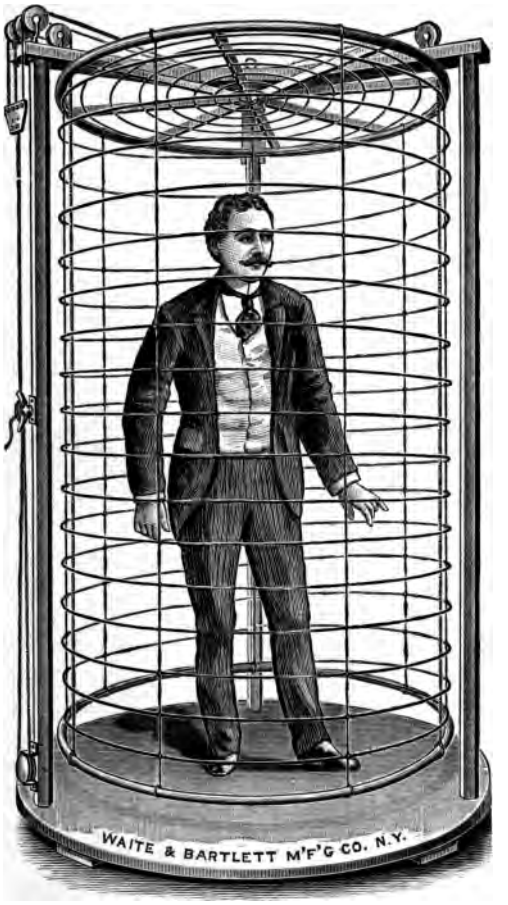


FIG. 68.—AUTO-CONDUCTION CAGE.

ing or reclining inside the cage and forming a secondary circuit, high-frequency currents being induced directly in the tissues of the body.

(II) *D'Arsonval auto-condensation* is, perhaps, the most valuable of all high-frequency modalities. As implied by the name, the patient's body forms a part of an accessory condenser circuit derived from the d'Arsonval solenoid. In giving an auto-condensation treatment the patient is placed on a chair or couch of insulating material, to the under side of which is attached a plate of thin copper or other metal; this forms one plate of the condenser, the patient takes the place of the second plate, and the insulating medium between the two form the "dialectric."

In d'Arsonval's original experiments, rubber covered pads three inches thick were used as dialectrics, the current used being derived from a solenoid excited by a Ruhmkorff coil or static machine. This method is called "High-voltage auto-condensation."

A few years ago a new type of apparatus was introduced which employed a high-frequency current of from 15,000 to 30,000 volts, derived from alternating current transformers. By using a thin dialectric formed of a sheet either of vulcanized fiber or "bakelite," not over ¼ in. thick, it was found possible to administer very high amperage by auto-condensation. Nagelschmidt, of Berlin, reports the use of currents as high as 12,000 milliamperes derived from a special un-

damped wave apparatus. Dr. Frederick DeKraft, of New York, who has developed the low-voltage auto-condensation method in this country, does not advise the employment of

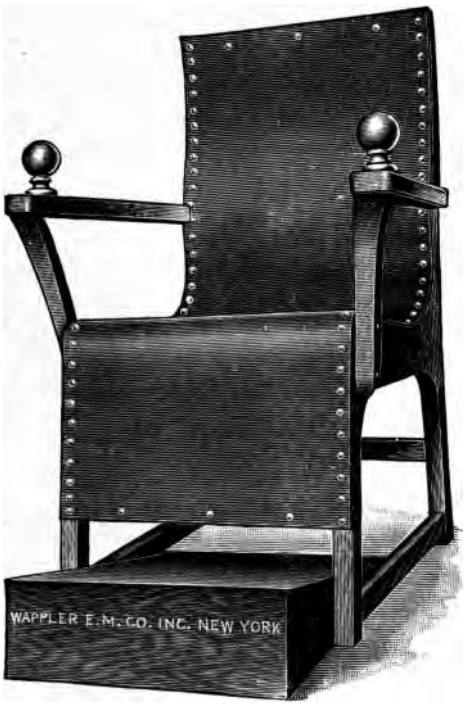


FIG. 69.—DEKRAFT AUTO CONDENSATION CHAIR.

more than 1,000 milliamperes in auto-condensation, 800 milliamperes being a safe amount for the average case.

There is no doubt but that each of these methods has its especial field. In general, it

may be said that high voltage auto-condensation with thick dialectric produces a stimulant-vitalizing effect, and is to be preferred in cases of lowered nervous energy and advanced cases of arteriosclerosis where the vital forces are much impaired; while in cases of auto-toxæmia and poor elimination in otherwise well-nourished subjects, with high blood pressure, the best results follow the use of low voltage auto-condensation with the thin dialectric. Pushing the current to the point of "sweating" the patient is a dangerous practice, and should only be employed by those who have had much experience in the use of electricity. The indications for the use of auto-condensation in various diseases will be considered in the chapter on Special Therapeutics.

Local *auto-condensation* is a method of great value when we wish to obtain the vitalizing hyperæmia of diathermy simultaneously with the general effects of auto-condensation. The patient sits or reclines upon the pad or couch (thin dialectric), and the block-tin diathermy electrode, applied to the area to be treated, is substituted for the metal hand electrodes ordinarily used in auto-condensation. The best results from auto-condensation treatment in chronic cases are obtained by giving mild doses (400 to 600 milliamperes) daily for weeks or even months. Apparatus is available which may be installed in the patient's home: a folding pad is used instead of the couch or chair, and the treatment adminis-

tered by the patient's attendant. (See Fig. 70.)

D'Arsonval currents owe their therapeutic value mainly to their stimulating action on the chemical processes of the organism. They increase tissue combustion and oxidation, and facilitate the elimination of waste-products. Nitrogenous débris, which would otherwise

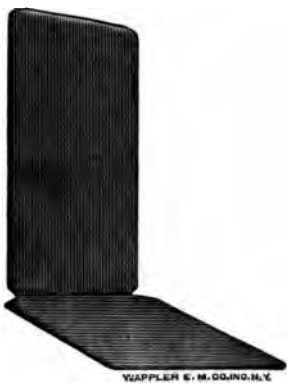


FIG. 70.—FOLDING AUTO CONDENSATION PAD.

form uric acid, is converted into urea, and the peripheral circulation is increased through vaso-motor stimulation. In addition to these effects, the d'Arsonval current is of value for the relief of acute congestion and stasis, as in the early stages of pneumonia, bronchitis, tonsillitis, etc. To obtain these effects the current should be used directly, by the diathermic method, or by "local auto-condensation."

8. A modern high-frequency apparatus for the use of the general practitioner should give currents suitable for auto-

condensation and diathermy as well as high voltage currents for treatment by vacuum electrodes, "effluve" or spray, and high-frequency sparks or "fulguration." Many standard high-frequency outfits give sufficient current to operate X-ray tubes for ordinary skiagraphic or fluoroscopic examination.

Several forms of apparatus for the production of therapeutic high-frequency currents are shown in the annexed illustrations. They are designed primarily for use with the 104-volt, 60-cycle alternating current, but may be employed on a direct current circuit by the use of a *rotary converter.* The latter consists of a direct current motor, provided with a pair of insulated collector rings which are connected respectively to opposite points of the armature winding. A portion of the 110-volt direct current which excites the converter causes the rapid revolution of the armature, as in an ordinary motor; the remainder passes from the armature coil to brushes bearing on the collector rings, forming an alternating current of from 80 volts and of a frequency corresponding to the number of revolutions per minute of the armature shaft. The current thus produced will operate any of the high-frequency machines illustrated, as well as the commercial alternating current, except that a smaller *choke coil* must be used on account of the difference in voltage of the two circuits.

9. The large machine illustrated in Fig. 71 was designed by the writer some fifteen years ago. It has not been manufactured for some years, but many of the originals are still in use and giving good satisfaction. It was not possible to obtain auto-condensation or diathermy from these machines, but for Tesla currents they were excellent. By the use of the triple terminals as shown, a number of interesting and valuable effects could be obtained. Adding these terminals to any modern high-frequency machine giving bipolar Tesla currents will add greatly to their usefulness.

FIG. 71.—DR. STRONG'S "HERCULES" HIGH-FREQUENCY APPARATUS.
(No longer manufactured.)

10. For the benefit of those physicians who may wish to construct their own apparatus, the following directions are given; if carefully followed, an outfit will be produced at a very moderate cost, capable of giving any and all of the currents that are used in high-frequency therapeutics.

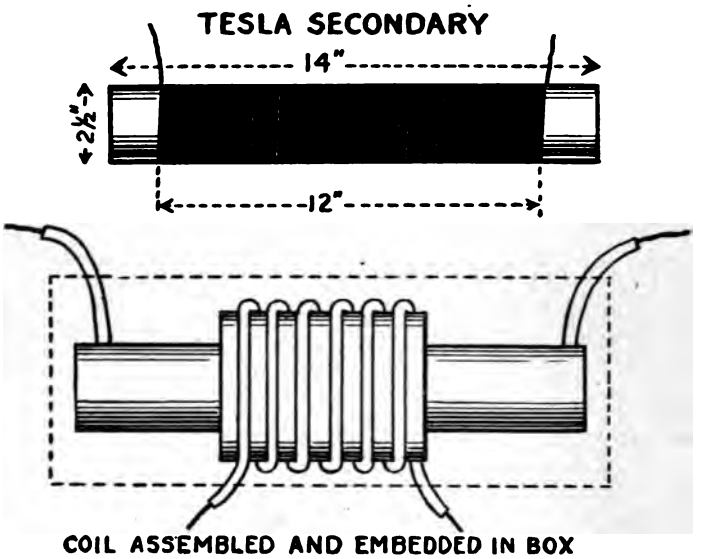


FIG. 72.—CONSTRUCTION OF TESLA HIGH-FREQUENCY COIL.

11. Any one who possesses a ¼ or ½ K.W. "wireless" transformer, operating on 110 volt, 60 cycle alternating current, can easily construct an efficient high-frequency outfit for medical use. The complete equipment includes a .01 microfarad glass plate condenser, Tesla coil, inductance, spark gap and electrodes.

The Tesla coil is made as follows (see Fig. 72): On a paper mailing tube 2½ inches in diameter and 14 inches long, wind 480 turns of No. 34 double cotton covered mag-

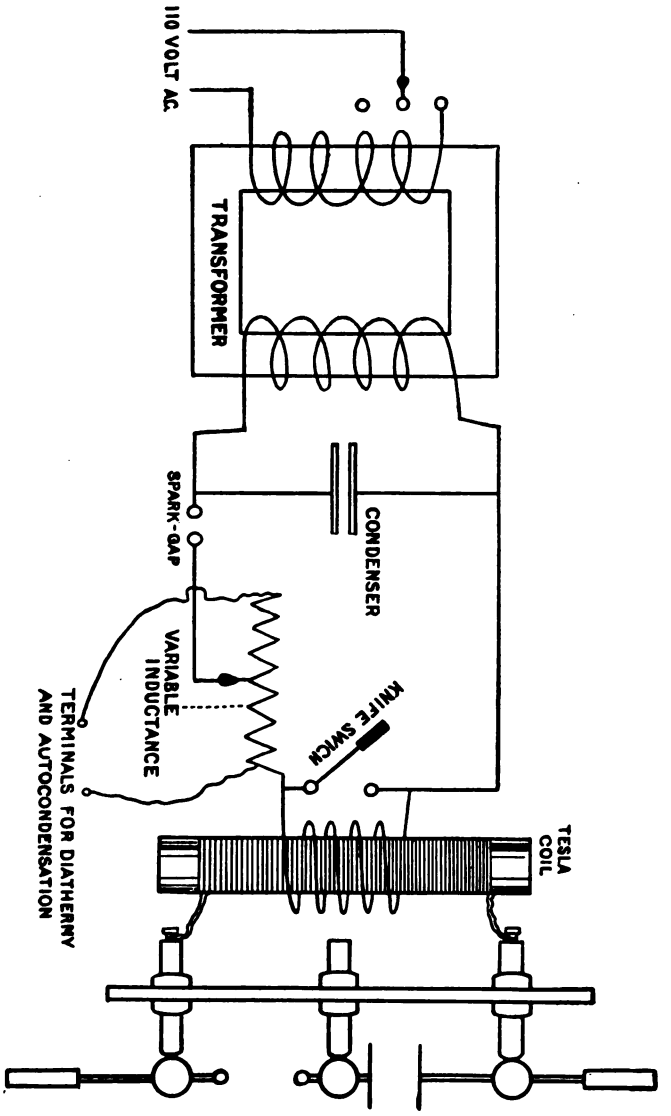


FIG. 73.—DIAGRAM OF CONNECTIONS FOR HOME-MADE HIGH-FREQUENCY APPARATUS.

net wire. Set up the tube in the lathe, applying a coat of orange shellac, spin on the wire, apply a second coat of shellac and allow to dry thoroughly. The winding occupies twelve inches, leaving a margin of one inch on each end of the tube. Leads of light auto cable are soldered to the ends of the winding. A strip of waxed corrugated paper five inches wide is wrapped around the center of the secondary tube and on this is wound the primary, consisting of four turns of heavy high-tension auto-cable, and thoroughly secured by tape; at least a foot of cable should project from each end of the winding to form the primary leads. Place the coil in a wax tight box made without nails and embed in a mixture of four parts rosin and one part beeswax. It is safer to boil the coil for an hour in the insulating mixture before placing it in the box. Coils made in this way by the writer are still giving good service after fifteen years of use.

The greatest source of trouble in a medical high-frequency outfit is the spark gap:—the one described below is the outcome of many years experiment. If properly made it will run daily for months without deterioration. The gap takes place between two pieces of brass rod ¾ inch in diameter and 1 in. long, turned and tapped as shown. The sparking surfaces are turned in annular grooves with a 60 degree tool. If your lathe has an automatic cross feed, you may set it to twenty turns to the inch and turn a spiral groove instead of the annular rings. After finishing, the brass pieces are *heavily silver-plated* and mounted in the usual manner, as shown. For currents over ¼ K.W. a plate of silver should be soldered to the brass before turning the grooves. For very heavy currents two of these gaps should be used, connected in series.

The connections for the various parts of the apparatus are shown in Fig. 73. An important feature is the use of an outside inductance or tuning coil in series with the

Tesla coil. It consists of 32 turns of No. 8 bare copper wire wound on a frame 8 inches in diameter, with ¼ in. between turns. Edgewise-wound flat copper strip is better, but more expensive. This coil, when used in series with the Tesla primary, enables us to tune the oscillating system in perfect resonance when the capacity of the patient's body is added to the Tesla terminal. Effects are produced which are impossible with any other method. The beautiful "high-

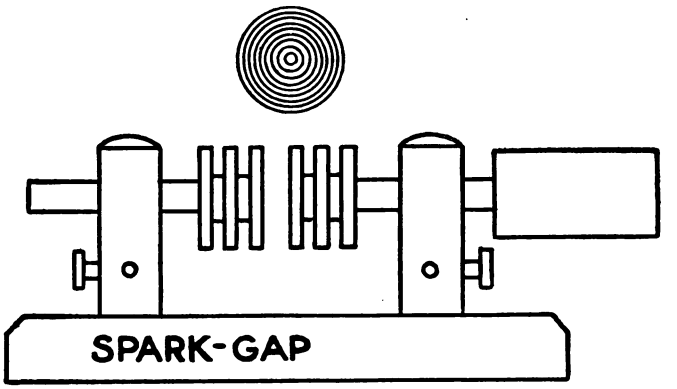


FIG. 74.—ADJUSTABLE SPARK GAP.

frequency *effluve,*" or brush discharge, so valuable in treating pulmonary diseases, and which so few modern high-frequency machines can produce, is obtainable by the use of this series inductance. It may also be used by short-circuiting the Tesla primary, as an auto-transformer from which may be derived heavy d'Arsonval and diathermic currents. The leads from the Tesla coil should be connected with the outside posts of the author's triple terminals, described above.

12. The physical properties of the current may be studied by manipulating the triple terminals with which all of the writer's machines were provided. By pushing in the handle

of the right and left terminals a circuit will be formed through the insulated center terminal, which is called a *"dummy"*; by pulling out the right-hand sliding rod, while the machine is in operation, the current will discharge in the form of a flaming *arc,* a pencil of light, of an apparently continuous character between the small brass balls of the terminal rod and the "dummy." This arc is a true *electric flame,* and will light a candle or stick of wood in the same way as a gas flame. Its intense heat is shown by the combustion of a piece of fine iron wire when held in a pair of forceps near the right-hand terminal ball. If the arc be viewed in a tilting mirror, it will be broken up into a series of groups, each formed of a number of distinct arcs separated by dark spaces. By making the spark-gap as wide as possible, the secondary oscillations are "damped" and the arc is changed to a sparklike discharge, which the writer has termed the *"pseudo-static spark."* By pushing the two terminal balls together, and separating the disks, a beautiful purple *effluve* will be formed, composed of hundreds of fine threadlike purple sparks. This effluve is made up of alternating streams of *positive ions* moving at a high rate of speed. By placing a perfectly flat card or photograph mount in close contact with one of the disks, the ions will be prevented from discharging on that side, and the force of the ionic bombardment from the opposite disk will be sufficient to support the card in its position, and a considerable effort will be necessary in order to remove it. If the disks be pushed into contact and a piece of plate glass interposed between the brass balls, the discharge will spread out on either side of the glass, forming a beautiful rosette of radiating sparks. If allowed to continue, the discharge will heat the glass in a line between the balls, and in a few moments will actually melt a hole through the plate. The latter experiment should be performed with a piece of thin window glass,

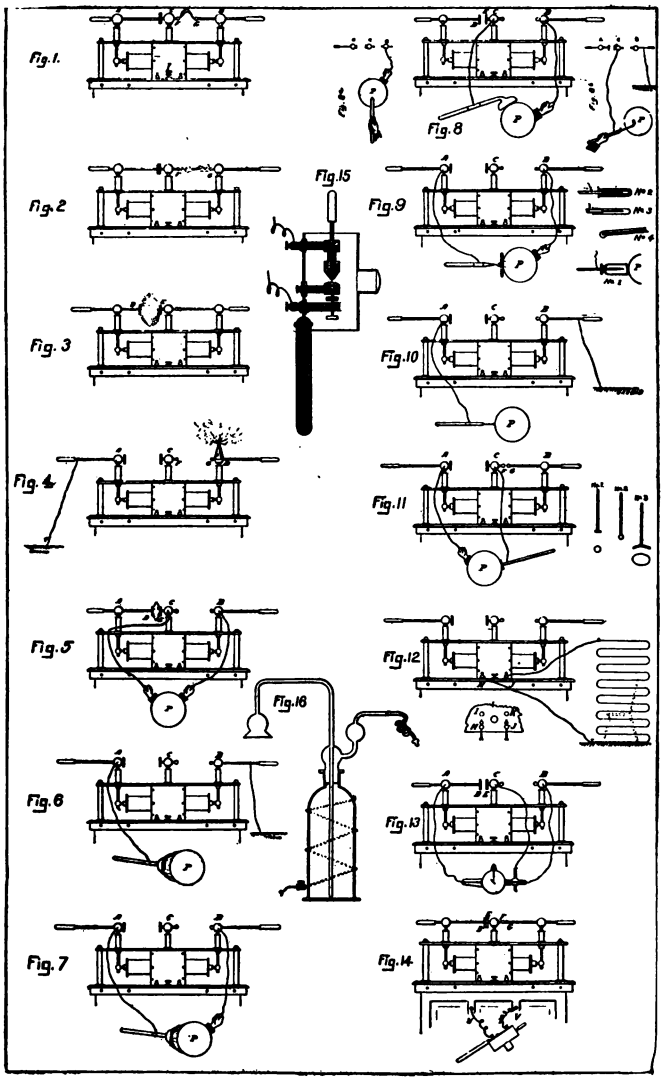


FIG. 75.—REDUCED COPY OF CHART SHOWING METHODS OF OBTAINING VARIOUS HIGH-FREQUENCY MODALITIES FROM MACHINES EQUIPPED WITH DR. STRONG'S TRIPLE TERMINALS.

as the unequal expansion is liable to cause a thicker glass to explode.

13. If a long glass tube, sealed at one end, be attached to a rubber tube connected to a powerful air-pump, and a wire from each terminal of the high-frequency apparatus be wound around the tube at each extremity, no evidence of the passage of a current will be seen on starting the apparatus. If, now, the air be slowly withdrawn from the tube, a faint blue thread will appear, changing to a red-violet pencil of light, extending through the tube between the points where the wires are attached. The first thread-like flicker occurs when all but one-fifth of the original air has been removed, and the red pencil when only one-twentieth of the air remains. Increasing the exhaustion to one five-hundredth causes the pencil of light to enlarge until it completely fills the tube. From this point up to one ten-thousandth of an atmosphere causes the light to change from a red-violet to red-pink, pink, pale rose, and finally pure white. With a good mercury pump we can carry the exhaustion still further, and at one fifty-thousandth the inner surface of the glass shows an apple-green fluorescence. At one one-hundred-thousandth most of the white light has disappeared, and at one one-millionth it has completely gone and the tube appears empty, but the green fluorescence has become more intense. We have now in the tube what is known as a "Crookes vacuum," the condition necessary for the production of the *"X-rays of Roentgen."*

14. In 1896 the writer constructed several instruments for applying the high-frequency current to the human body, consisting of glass tubes from which most of the air had been exhausted, fitted with insulating handles. In this way the advantages of vacuum tubes for administering high-frequency currents in the treatment of local conditions was discovered, and the vacuum electrode was introduced into elec-

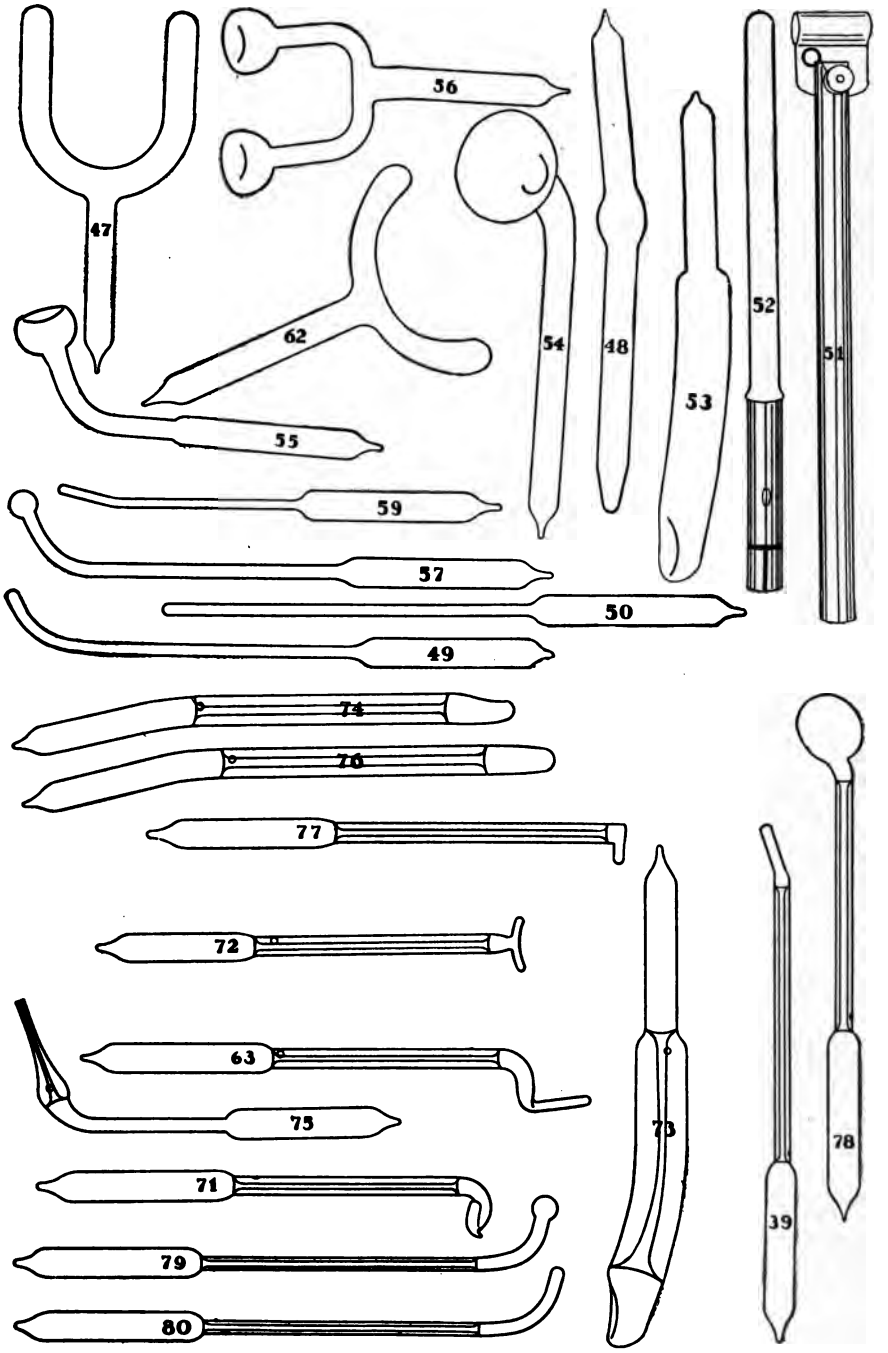


FIG. 76.—VACUUM ELECTRODES.

tro therapeutics. It is now in general use in all parts of the world, and is regarded as one of the most important factors in the treatment of disease by high-potential currents. When

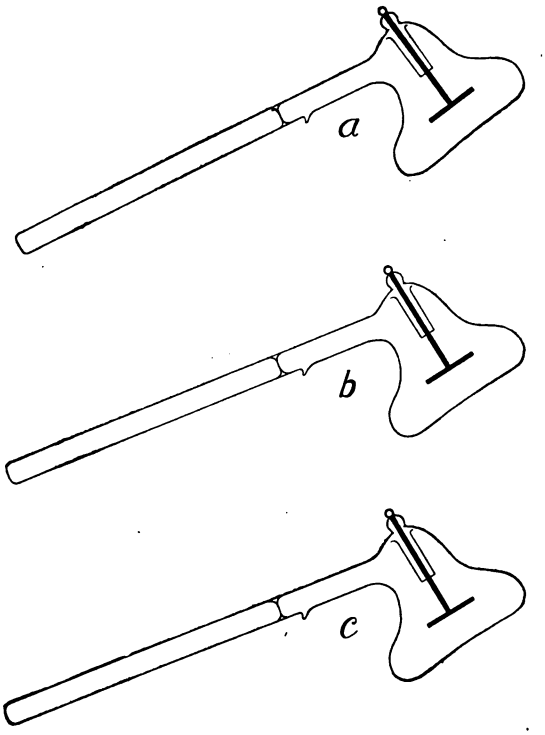


FIG. 77.—DR. STRONG'S SET OF GRADUATED VACUUM CONDENSER ELECTRODES, EXHAUSTED TO—*a*, Low ("Red"), *b*, High ("White"), *c*, Very High ("X-ray Vacuum").

first introduced by the writer, however, it was denounced by the profession as a "spectacular toy."

15. When vacuum electrodes are used in therapeutic application of high-frequency current a twofold effect is produced:

a. A general effect due to the action of the high-frequency current, which increases metabolism, relieves congestion, stimulates the vaso-motor system and promotes nutrition and vital resistance. If a vacuum electrode is connected directly to the terminal of a resonator, the effects just mentioned will be confined to the tissues in the vicinity of the area treated. But if the electrode be used to draw off the resonator current from the patient, or if the writer's bi-polar technique be employed, the entire organism will be subjected to the vitalizing effect of the current.

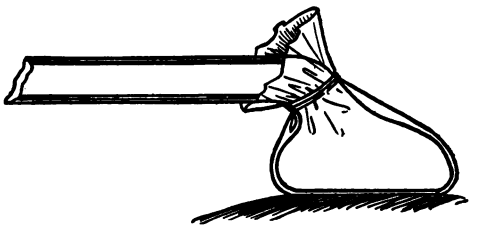


FIG. 78.—VACUUM ELECTRODE, COVERED WITH FLANNEL OR CHAMOIS SKIN, FOR SUPERFICIAL COUNTER-IRRITATION.

b. The second effect is purely *local* and more or less superficial, and results from the action of *ether waves* of *radiant energy* generated by the electronic vibration in the vacuum tube. The nature of the effect depends upon the *wave length* and *frequency* of the rays, or, in other words, results from the degree of exhaustion in the tube. The majority of vacuum electrodes possess what is called a *"low red vacuum,"* on account of the red-violet color produced in the tube. Electrodes of this type, when excited by a resonator or Tesla current, produce local sedative effects, disperse inflammation and acute congestion, sterilize superficial septic areas by the generation of ozone and nitrous vapors, promote phagocytosis, stimulate secretion and absorption, and relieve acute

local pain. For the treatment of muscular and articular rheumatism, spinal irritation and congestive headaches, the electrode should be applied through the clothing, or still better, should be temporarily covered with one or more layers of thin flannel, which should be stretched over the bulb and gathered with a rubber band. With this arrangement the current comes from the electrode in a series of *fine sparks* which produce slight counter-irritation and stimulate the peripheral nerves. It is well to use the electrode for a few minutes in direct contact with the skin, and then repeat the process with the cloth-covered electrode. For the treatment of subacute or chronic inflammation, passive congestion or hypertrophy, a so-called *"white-vacuum electrode"* should be used, exhausted to about one ten-thousandth of an atmosphere. Persistent gleet, enlarged prostate, chronic endometritis, hypertrophic rhinitis, and ozena are conditions in which treatment with the white-vacuum electrode is indicated.

Obstinate neuralgic pain which refuses to yield to treatment with low vacuum electrodes is frequently relieved by substituting a tube exhausted to a white-vacuum. For the treatment of indolent ulcers, tubercular lesions, and superficial cancers, an electrode should be used exhausted to an "X-ray vacuum." The writer has devised a set of three *"condenser electrodes"* exhausted respectively to a *red, white,* and *X-ray vacuum.* Their action is similar to that of the ordinary vacuum electrodes, but the local effects are much more powerful.

16. The discharge from a resonator or Tesla coil is also used for the treatment of local conditions in the form of the *"Effluve"* and the *"Resonator spark."* The former is applied by means of a wire brush or metal point electrode, connected directly to the resonator terminal. It produces superficial reaction, varying from a slight erythema to actual

blistering, accompanied by intense stimulation of the local circulation, and a more or less general increase in the activity of the vaso-motor system. Resonator sparks are sometimes employed in cases of paralysis, and as a substitute for cauterization in spinal diseases. A metal point electrode is used, which is carefully moved toward the affected area until the spark passes.

17. Short sparks derived from Tesla, Oudin, or d'Arsonval circuits are now employed in the destruction of redundant tissues, such as moles, papillomata, hemorrhoids, etc. A

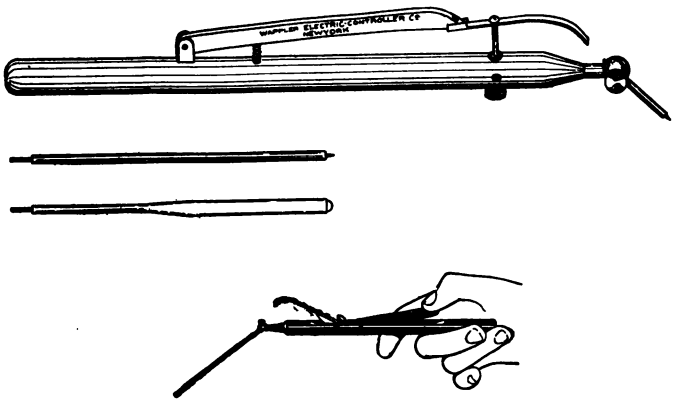


FIG. 79.—FULGURATION ELECTRODES.

metal point electrode is employed as illustrated. This method is known as "fulguration," and was introduced by Dr. Keating Hart. A short, hot spark from a d'Arsonval or Tesla apparatus quickly coagulates and destroys tissue. An anæsthetic must be used with this method. The so-called "cold spark" is obtained from an Oudin resonator; it is less painful and produces a desiccation of the tissue treated.

18. For general high-frequency treatment with Tesla cur-

rents, one pole of the apparatus is connected with the patient by a metal hand electrode, a similar electrode in the other hand being connected with the "dummy" terminal; both the disks and balls are separated at the beginning of the treatment. If the disks be now brought together until an effluve passes between them, the patient will experience a sensation

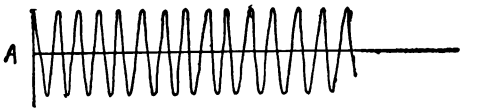


FIG. 80.—*A*, Theoretical Curve of a Pure Undamped Tesla Current.

like that produced by a faradic coil, attended with slight muscular contraction in the wrist, due to the production of *low-frequency impulses* in the *high-frequency stream.* This is an example of the writer's *"multi-frequency currents,"* in

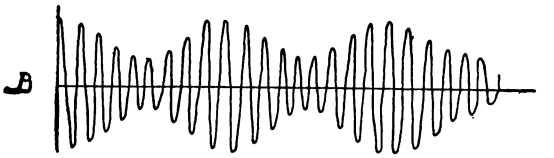


FIG. 81.—*B*, Same Current Carrying a Superimposed Wave of Lower-Frequency: Dr. Strong's "Multi-Frequency Current."

which electrical vibrations of different frequencies are administered to the patient simultaneously. Widely different therapeutic effects are produced by different combinations of vibrations. The extreme frequency of the Tesla current and the freedom with which it passes through the tissues, renders it an ideal medium or carrier for electrical vibrations of lower frequencies.

Believing that the various functions of the body are maintained or performed by the action of nerve vibrations of different, yet definite, frequencies, the writer is firmly convinced that the successful elimination of disease and the maintenance of a high standard of health will be brought about by an intelligent and scientific employment of electrical vibrations, through the elaboration of the principle of synchronism.

19. For the physician who does not care to study in detail

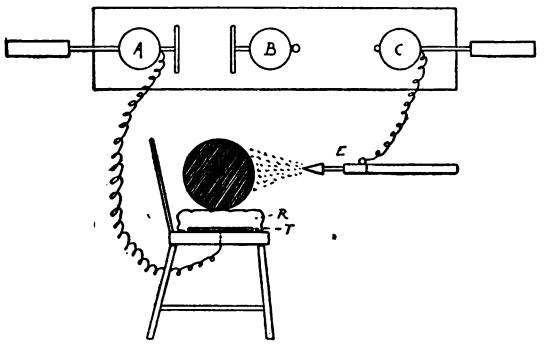


FIG. 82.—"AUTO-CONDENSATION EFFLUVE" FROM CURRENT OF HIGH POTENTIAL AND FREQUENCY.
A B C, Tesla-coil Terminals. *E*, Metal point Electrode. *T*, Metal Plate, in *R*, Rubber-covered Cushion. *P*, Patient.

the various methods for the application of the Tesla currents, the following technique may be recommended:

A circular plate of zinc about a foot in diameter is permanently connected to a rubber-covered conducting cord, which is attached to one terminal of a Tesla apparatus. The plate is set upon a chair and upon it is placed a thick cushion, the bottom of which is formed of sheet rubber; the patient sits upon this cushion and is then treated by means of the *"effluve," spark, or vacuum electrode,* connected

either to the other terminal of the Tesla coil or to the grounded wire. The terminal to which the electrode is attached is used in exactly the same way as the pole of a resonator, and the same local action is produced, with the addition of the constitutional effects in the preceding paragraphs. A fiber condenser pad, such as is used in low-voltage auto-condensation, may be used instead of the cushion above described.

CHAPTER IX

THE ROENTGEN RAYS

1. In all the history of scientific achievement, there has been perhaps no discovery of such a startling and revolutionary character as that of the X-ray. The Electron Theory, which forms the basis of the chemistry and physics of our new age, has been formulated almost entirely from deductions made possible by the work of Roentgen and the Curies. If we review the history of these discoveries we find that they have resulted from a long series of researches dealing with the phenomena of electrical discharges in partial vacua. The air pump was invented in 1650 by Otto von Guericke; by its use Sir W. Snow Harris, in 1834, was able to show that the spark-length of a given electrical machine increases in inverse ratio to the pressure of the gas through which it passes. His tubes were exhausted to about one five-hundredth of an atmosphere, and the discharge took the form of a pencil of violet-pink light. Geissler, in 1838, experimented with discharges of low vacua, and invented the beautiful tubes which bear his name. By improving the air-pump he was able to withdraw all but one ten-thousandth of the original air from the glass tube, and change the color of the glow in the electrified space from violet-pink to a pure white. The invention of the mercury air-pump by Sprengel, in 1865, made it possible for Sir Wm. Crookes, in 1878, to study electrical discharges in rarefied gases with pressures as low as one one-millionth of an atmosphere. He gave to the world the "Crookes tube," with which Lenard, in 1894, proved the existence of the "Cathode rays," and from which, in 1895, Roentgen accidentally discovered a

new form of emitted energy which he tentatively called the "X-ray." We all recall the circumstances of this discovery: Roentgen was experimenting with a Crookes tube enveloped in an opaque cover, when he noticed a bright glow on a nearby card, coated with Platinum-Barium-Cyanide. The glow continued even when the uncoated surface of the card was presented to the tube, and further experiment showed that the interposition of the experimenter's hand between the covered tube and the fluorescent screen would cause a shadow-picture of the bones to appear upon the glowing surface. The publication of Roentgen's discovery led investigators in all parts of the world to study the new phenomena. Static machines and Ruhmkorff induction coils were at first employed to excite the Crookes tubes, but the intensity of the resulting X-rays was not very great. In those days an induction coil giving a four-inch spark was regarded as exceedingly powerful. We know now that such an apparatus is entirely inadequate to the production of X-rays for any practical purpose. Tesla and Elihu Thompson advocated high-frequency currents for X-ray generation, and in 1896 the Knott Apparatus Co., of Boston, designed the first practical commercial X-ray machine. It consisted of an open-core transformer, glass-plate condenser and Tesla coil, immersed in oil, and a rotary spark-gap not unlike those now used in radio-telegraphy. A few months later the writer made the first practical high-frequency apparatus having solid insulation instead of oil, and suitable for therapeutic as well as X-ray work. The many types of high-frequency machines that are now made for physician's use are but variations and improvements of this original apparatus. At the present time the professional Roentgenologist uses almost exclusively powerful apparatus of the high-tension transformer type, the high-voltage, low-frequency, alternating current being rectified by a high-tension com-

mutator operated by a synchronous motor. With such an apparatus and suitable X-ray tubes a skiagram of the adult thorax or abdomen may be made in the fraction of a second. For the general practitioner, the dentist, and the amateur experimenter, however, the high-frequency apparatus is still the most convenient and inexpensive device for exciting X-ray tubes, and produces results quite adequate to their respective needs.

2. The *X-rays* are *waves* or *pulses* in the ether of very

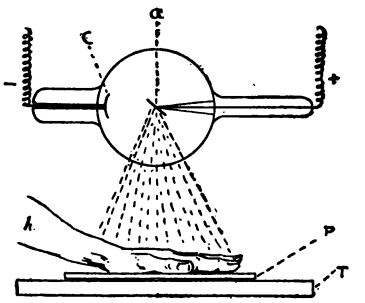


FIG. 83.—METHOD OF TAKING A "SKIAGRAPH."
a, Anode. *c*, Cathode. *h*, Hand of Patient. *P*, Sensitive Plate Enclosed in Opaque Envelope. *T*, Table.

high-frequency, and a wave-length so short that they pass through many solid bodies almost as readily as light passes through glass. Metals, and, as a rule, other solid substances, absorb the X-rays in a degree proportioned to their density; thus heavy metals, like lead and iron, are almost opaque, while aluminum, which is light, offers but little resistance to their passage. There are certain exceptions to the above rule, notably the diamond, which is almost transparent, while glass and quartz absorb a large percentage of the rays. The human bones are moderately opaque, the organs and muscles less so; the lungs, on account of their spongy character, being almost transparent.

3. The X-rays are invisible to the human eye, but may be converted into light by the use of screens of cardboard coated with some highly fluorescent substance such as Barium platinum cyanide, Calcium tungstate, Willemite, etc. Screens of this character become luminous in proportion to the strength of the X-rays which fall upon them. If the hand be held between such a screen and a source of X-rays, the

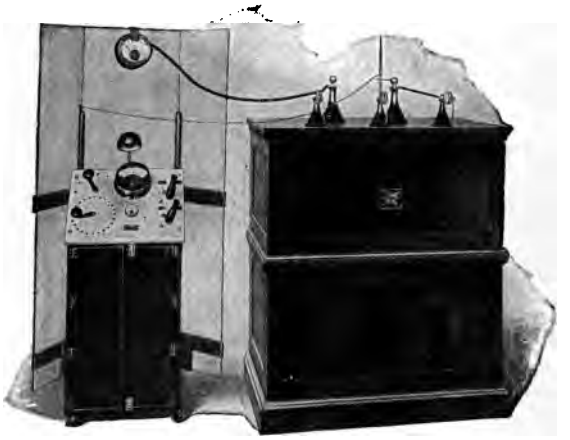


FIG. 84.—HIGH TENSION TRANSFORMER TYPE OF X-RAY APPARATUS.

bones, which absorb most of the rays, will appear as dark shadows. The flesh, which allows more of the X-rays to pass, cast a lighter shadow, while the unimpeded rays will cause the remainder of the screen to be brilliantly illuminated. We speak of "Seeing the bones through a fluoroscope," but in reality we are looking at a "Shadow-picture," produced by the conversion of the X-rays into light by the fluorescent chemical on the screen.

4. If a sensitive photographic plate, sealed in an opaque envelope, be substituted for the fluorescent screen in the

above experiment, the X-rays will produce the same effect as light, and on development a permanent picture or skiagraphic negative will be obtained. The length of the exposure will depend on the intensity of the rays and the thickness of the tissue through which they pass.

5. X-ray tubes are of three types, intended for use respectively with a *Static machine,* a *Tesla apparatus,* and a *Ruhmkorff coil,* or transformer. The static tube is of the simplest construction, and consists of an *aluminum* cathode, shaped like a *concave reflector,* and a *platinum* anode placed

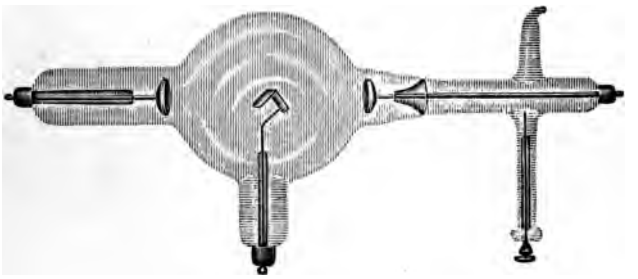


FIG. 85.—THOMPSON DOUBLE-FOCUS TUBE FOR USING BOTH PHASES OF A HIGH-FREQUENCY CURRENT.

in the focus of the rays from the cathode, and at an angle of 45 degrees with the axis of the tube. When in operation, the "cathode rays," consisting of streams of electrons, are projected from the surface of the cathode with the velocity nearly that of light, and strike the anode at a common focus, from which they are reflected at right angles toward the side of the tube. At this point each electron is stopped, but the *impulse* which it has communicated to the ether is transmitted to the space outside the tube in a line continuous with the path of the electron.

It will be seen, therefore, that X-rays radiate from a point, and that their intensity is inversely proportional to

the square of the distance from the anode. This fact should be considered in determining the time of exposure in taking a skiagraph. The penetrability of X-rays increases with the degree of exhaustion or electrical resistance of the tube. Tubes of high exhaustion are called "hard tubes," and are used in examining thick structures such as the trunk and thigh. They require a high voltage. Static tubes are of this type, but few static machines furnish sufficient amperage for heavy X-ray work. With a Ruhmkorff coil, "soft tubes"

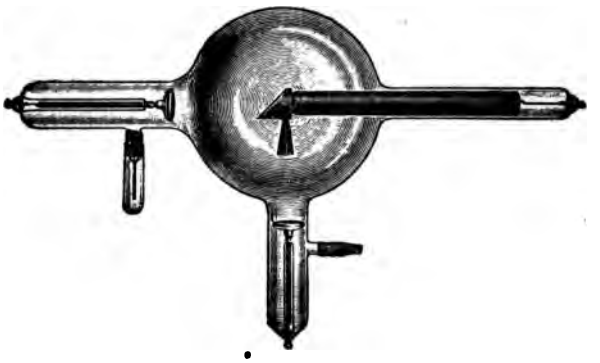


FIG. 86.—HIGH-FREQUENCY TUBE USING THE ALTERNATIONS IN ONE DIRECTION ONLY.

having a lower degree of exhaustion are generally employed. They require less voltage than hard tubes, but a large amperage must be used in order to obtain penetration, the rays from these tubes being more readily absorbed. The tubes get very hot and require heavy anodes or water-chambers to disperse the heat. The degree of exhaustion gradually increases through constant use, some of the residual air particles being driven into the glass or absorbed by the platinum or tungsten anode when the tube is in operation. When the resistance becomes too high the *"vacuum"* may be *"lowered"* by admitting hydrogen gas through the pores of a red-hot

palladium tube, or by liberating oxygen by heating manganese dioxide contained in a small side-tube. Some tubes liberate gas automatically when their resistance becomes too high, and are said to be "self-regulating." For use with a Tesla current a special form of tube is necessary, owing to

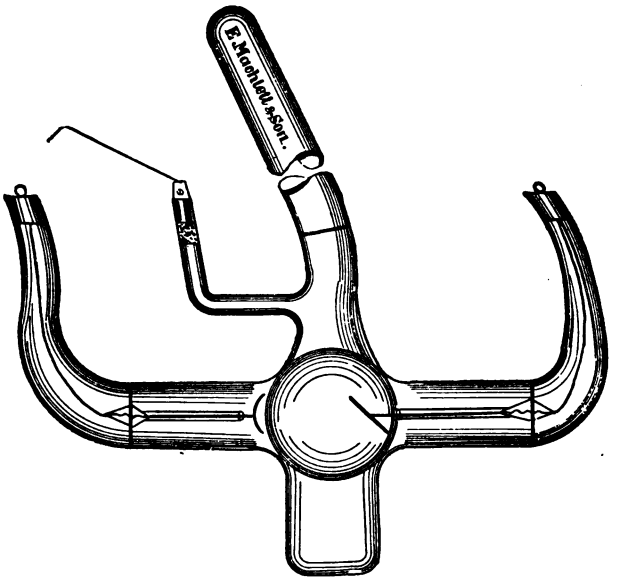


FIG. 87.—DR. GEYSER'S "CORNELL" TUBE (APPLIED DIRECTLY TO THE SURFACE TO BE TREATED).

the alternating character of the electrical impulses. In the *Thompson double-focus tube* the terminals of the coil are connected to two cathodes, each of which is provided with a platinum target or reflector, formed of a single "V-shaped" plate. The rays are sent out in parallel streams, first on one side of the apex of the platinum V, and then on the other. In a well made tube the two streams coalesce and act as

one, but if the cathodes are not accurately focused, a double outline will be produced on the plate or screen.* For accurate work, therefore, it is better to employ a tube in which one set of cathode rays is choked, or deflected so as to allow but a *single stream* of X-rays to fall upon the plate. The details of these tubes may be seen in the accompanying illustrations.

6. X-rays have been extensively used in therapeutics in the treatment of cancer and lupus. The latest conclusions, however, seem to prove that the X-ray alone seldom pro-

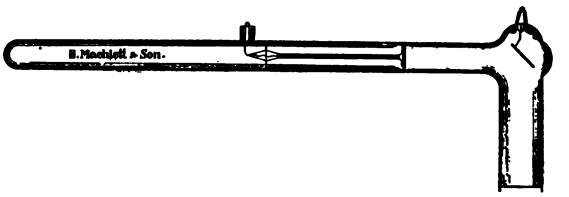


FIG. 88.—DR. BESSER'S THERAPEUTIC X-RAY TUBE FOR SMALL AREA.

duces cures. A great drawback to the therapeutic use of X-rays from a static machine or a Ruhmkorff coil is the liability of producing serious burns of the superficial tissues, accompanied by extensive necrosis, and requiring weeks or months to heal. The use of a *diffused X-ray,* combined with the high-frequency current, as in treatment with the writer's "X-ray electrodes," has given excellent results in malignant growths, lupus, chronic ulcers, and other indolent conditions.

7. General medical practitioners using X-ray outfits often desire to view considerable areas of the body simultaneously; this can be done only by using a large fluorescent screen and covering the X-ray tube with opaque material. Ordinary fluorescent screens are coated with barium-platinum cyanide,

*Thompson double-focus tubes are now practically obsolete for the above reason.

and cost about 25 cents per square inch. This would make a screen large enough to view the thorax (10 x 12 in.) cost thirty dollars—a prohibitive figure for most general practitioners. A very good screen, however, may be easily made by evenly coating a sheet of white cardboard with a solution of sodium silicate and immediately sifting on finely powdered *calcium tungstate.* Gently raise the screen on its edge and tap it to shake off the excess of tungstate; then allow it to dry. While not as brilliant as the platinum screens, such a screen will fulfil all ordinary requirements and may be made at a cost of not over two dollars. A still simpler experi-

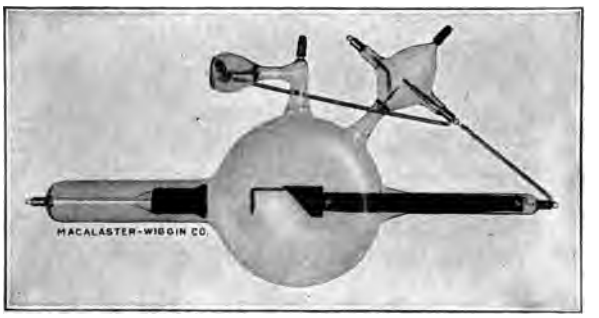


FIG. 89.—HYDROGEN TUBE FOR USE WITH HEAVY TRANSFORMERS.

mental screen may be made by painting a card several times with a strong solution of quinine bi-sulphate. Home-made screens coated with ordinary luminous paint will be found interesting for the experimenter; they are phosphorescent rather than fluorescent, and retain the image for some time.

8. No one should attempt to work with the X-rays for any length of time without protecting himself with gloves and apron coated with "tea lead" or heavy tin foil. Many of our best X-ray experts have lost their lives through neglect of this precaution.

CHAPTER X

DENTAL ELECTRO THERAPEUTICS

1. Electricity in its various forms is rapidly coming into general use among dentists.

Ionization with the continuous current has proven of great value in treating infected root-canals, alveolar abscesses, neuralgia, etc.

High-frequency currents of the Tesla type, applied through special vacuum electrodes, are exceedingly efficient in treating pyorrhea and in the relief of pain.

The introduction of the X-ray into dental practice has been followed by almost revolutionary results; by its use many otherwise obscure lesions are revealed, the relief of which is often followed by the disappearance of serious troubles of a reflex, local or systemic character.

For a full discussion of the theory and practice of electrotherapeutics in dentistry the reader is referred to the excellent work on "Dental Electro Therapeutics" by Dr. Ernest Sturridge, of London, from which much of the material for this chapter is taken.

2. In the chapter on Galvanism the general theory of ionization is given. Special apparatus is made for dentists adapting the 110-volt direct current for use in ionic medication. In this country a shunt coil of german silver wire is usually employed, with a sliding contact by which the resistance can be gradually increased or diminished, thereby throwing more or less current through the body of the patient.

The entire outfit for dental ionization consists of a switchboard composed of the variable resistance or shunt coil, a milliamperemeter, a pole-changing switch, conducting cords, and suitable electrodes. The usual source of electricity is the 110-volt direct electric lighting current. Where only the alternating current is available a motor-generator set is used, consisting of an alternating current motor directly

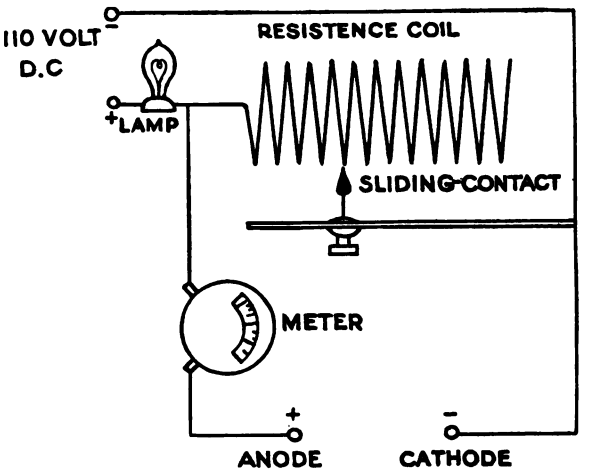


FIG. 90.—DIAGRAM OF SHUNT COIL FOR DENTAL IONIZATION TREATMENT.

connected to a small 100-volt direct current generator. Dry cell batteries in series may be used with a suitable resistance. (See chapter on Galvanism.)

The electrodes are of two kinds: the active, or dental, electrodes, from which the ions are driven, and the indifferent electrode. The latter is used to conduct the current into or away from the body, and is usually held in the hand or strapped to the wrist. It should be of carbon or heavy

block-tin, and covered with gauze or absorbent cotton, which is to be thoroughly moistened in salt solution and applied in close contact to the patient's skin.

Various forms of active electrodes are used; they are usually of zinc, copper or platinum wire, and are made to fit a common handle similar to the insulated needle or broach-holder used in destroying hair follicles. These electrodes have rounded, tapering ends, and may be bent to fit different cavities and surfaces. They are sometimes insulated up to one-half inch of the active extremity to protect the cheeks and lips.

Many forms of ionic medication have been successfully employed, those most generally used being copper, zinc, cocain and iodine.

For copper ionization the cavity, sinus or root-canal is filled with a three-per-cent. solution of copper sulphate, a copper anode inserted and a current of from 1 to 2 ma. passed for five to ten minutes. The same technique is used with the zinc ion, except that a three-per-cent. solution of zinc chloride is used.

Cocain ionization is used for local anesthesia in dental operations, a five-per-cent. solution of cocain hydrochlorate being applied to the cavity or membrane by means of a bit of absorbent cotton wrapped around a platinum wire electrode. Copper, zinc and cocain ions are all driven in from the positive pole or anode.

Iodin, being an acid-forming element, is driven in from the negative electrode or cathode. In practice, a ten-per-cent. solution of potassium iodide is used in the cavity or on a cotton-covered platinum wire electrode.

Copper, zinc and iodin are all employed for their antiseptic value; the zinc ion is generally used; it is effective in sterilizing ulcers, pyorrhea pockets, infected root-canals, and septic peridontal membrane.

The copper ion is used for similar purposes; it is especially recommended for sinuses, fistulas and tortuous canals, as the copper wire anode can be bent more readily than the zinc.

Anæsthesia by cocain ionization is more effective, of longer duration, and less apt to cause toxic effects than that produced by cocain injection.

Iodin ionization is recommended for its healing effects on the tissues. "Many cases of threatened pyorrhea and peridontal disease may be averted by treatment with this ion." (Sturridge.)

In commenting on the use of ionization in dentistry, Sturridge says: "The electrolytic effects on certain salts of an antiseptic nature whereby ions are transported into the tissues (and this with a very low current strength) opens up a field of usefulness to the dental profession of inestimable value. The natural susceptibility of the oral cavity to septic infection constitutes three-fourths of the greatest difficulties placed in the way of almost every operation the dentist is called upon to perform, the burning question ever being how to prevent or cure sepsis. If, then, an improvement on the ordinary method is placed at our disposal by the use of electric currents, it should be our duty to adopt it."

3. *High-frequency Currents in Dentistry.* The author believes he is entitled to the credit of first calling the attention of the dental profession to the value of high-frequency currents in their practice. In a paper read before the Massachusetts State Dental Association in 1900, he pointed out the value of Tesla vacuum treatment in oral and dental sepsis, and for the relief of pain and congestion. At the present time the majority of dentists include a high-frequency apparatus in their equipment, and it is rapidly becoming more and more popular as the benefits from its use are more generally realized.

FIG. 91.—DENTAL APPARATUS FOR X-RAY, HIGH-FREQUENCY AND IONIZATION.

Except for those who specialize in dental radiography—who usually employ transformers of the Snook type—the high-frequency currents will be found quite efficient for ordinary X-ray work as well as for vacuum electrode treatment, fulguration and diathermy. Several excellent dental electro-therapeutic outfits are equipped for all of these purposes, as well as for ionization.

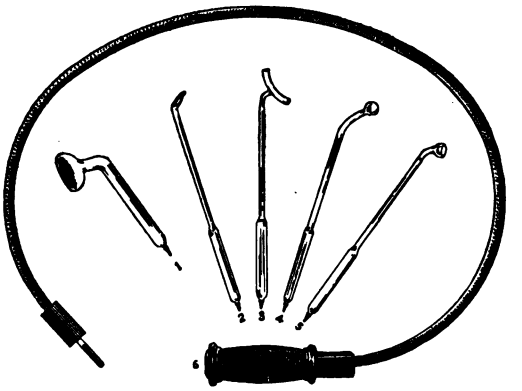


FIG. 92.—DENTAL VACUUM ELECTRODES.

The vacuum electrode has been adapted to the treatment of a variety of dental and oral diseases, and a number of forms are available; their general construction is shown in the accompanying illustration. The technique for the use of these electrodes is very simple; treatment is usually unipolar, the vacuum electrode being connected to the active terminal if the high-frequency apparatus is of the resonator type, or to one of the terminals of a Tesla coil. Very small current strengths are used, as a rule: hold the finger near the end of the vacuum electrode, and when a spark ¼ to

½ inch long jumps from the glass to the finger the current is of the strength ordinarily used in dentistry. In some cases of pyorrhea, where the electrode is applied directly to the gums, a heavier current may be employed. For fulguration the insulated metal point electrode is used, or the milder spark from the vacuum electrode. In the use of diathermy, small block-tin electrodes are employed on the skin or mucous membrane. The writer prefers to use a single tin electrode and connect the other terminal to the condenser pad upon which the patient is seated. The small folding pad of Bakelite fits the ordinary dental chair.

The high-frequency X-ray electrode is also used in dentistry, especially in the treatment of pyorrhea alveolaris. Dr. Tousey has devised a special X-ray tube for the treatment of this disease.

4. The use of the X-ray in dentistry for diagnostic purposes has proved of such great value that a large number of dentists now make skiagraphs in their own offices. Excellent dental X-ray laboratories have been founded in many large cities. The skiagraphs shown herewith were furnished by the courtesy of the Boston Dental X-ray Laboratory.

Dental X-ray technique varies with the type of apparatus employed. The dentist should obtain full instruction from the manufacturer who installs his apparatus. Further details may be obtained by consulting the excellent works of Sturridge and of Tousey.

The films which are used in dental X-ray work are supplied in small paper envelopes containing two superimposed films; they are usually held in position inside the mouth by the finger of the operator (always using a protective glove). One negative is retained by the dentist and one given to the patient. They are usually mounted in apertures in specially devised cards, upon which any necessary data may be written.

5. *Special Dental Electro Therapeutics.*

Abscesses. Vacuum electrode outside the affected area; zinc or copper ionization; diathermy in chronic cases.

Bleeding, persistent. Ionization with adrenalin solution; copper ionization.

Bleaching discolored teeth. Platinum wire electrode, surrounded by absorbent cotton soaked in bleaching solution; continuous current; 1 to 3 ma. Hubbell uses the high-frequency spark, driving in the bleaching solution by ionic bombardment.

Calculus deposits around roots in pyorrhea. All cases of pyorrhea should be X-rayed and calculus deposits removed, after which ionic treatment may be successfully used.

Chronic alveolar abscess. Sterilize root canal with zinc ions, and if sinus exists use copper ions.

Dead teeth, treatment of. Remove the pulp, fill canal with five-per-cent. zinc chloride solution, insert a platinum wire anode, and pass 3 to 5 ma. for five minutes. This will sterilize the entire area so that it may be filled and sealed. (Sturridge.)

Gingivitis. Silver ionization with "Argyrol" on cotton-covered anode.

Jaws, necrosis of. Iodin ionization; high-frequency sparks.

Neuralgia. Vacuum electrode applied over the affected nerve; diathermy.

Pulp anæsthesia. Cocain ionization. Novocain or pure phenol, driven in by spark from vacuum electrode.

Pyorrhea alveolaris (see "Calculus"), also treatment with special high-frequency vacuum electrodes. Pus pockets must be syringed out before treatment with high-frequency currents or by zinc ionization.

CHAPTER XI

THE SINUSOIDAL CURRENT

1. From a therapeutic standpoint a pure sinusoidal current is one in which the voltage slowly rises to a maximum and then slowly decreases to zero, at which point the current is reversed and a similar wave passes in the opposite direction. The term "sinusoidal" is used because the graphic representation of the current follows the trigonometrical "curve of sines."

2. If the impulses are all in one direction, we have what is called a "surging galvanic."

3. If the voltage of a rapidly alternating current be slowly raised and diminished in accordance with the sine curve, we have a "multiplex sinusoidal current." A standard apparatus giving all these currents of varying frequency is illustrated herewith.

4. Sinusoidal currents are applied by means of large flat metal electrodes covered with some absorbent material which is thoroughly soaked in hot water or salt solution. They are applied in firm contact with the skin.

5. Sinusoidal currents produce slow rhythmic contractions in both striped and unstriped muscle fiber, and are therefore used wherever we wish to increase growth, tone or function in muscles. Atonic conditions of the bowels, with constipation, pelvic adhesions, muscular atrophies, etc., are all benefited by the use of the sinusoidal current.

6. The latest improvement in sinusoidal apparatus is the invention of Dr. Frederick Morse, of Boston, and is described as follows:

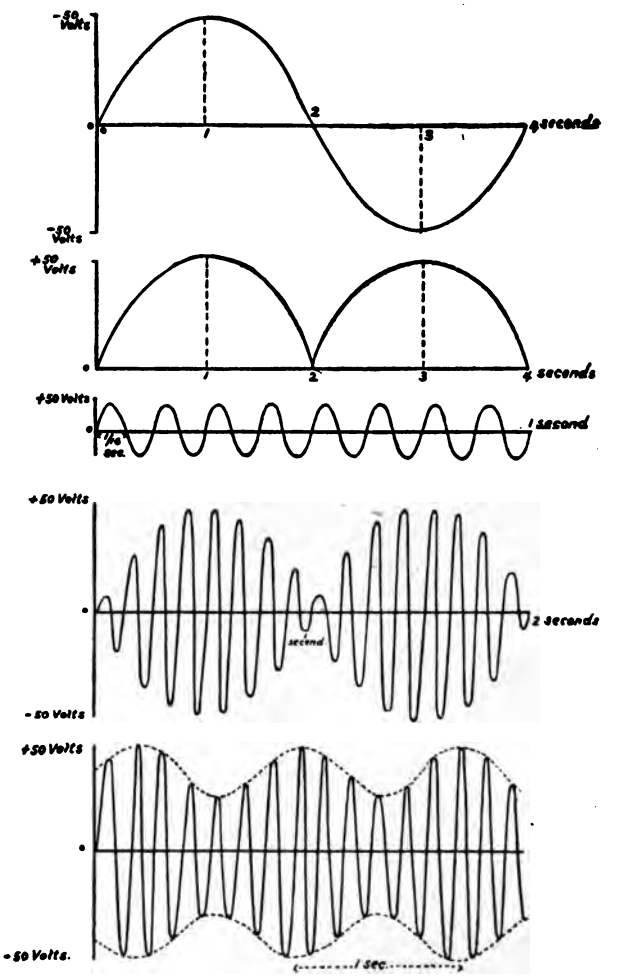


FIG. 93.—DRAWING OF CURVES.

"In literature published nearly twenty years ago on Electro-physics, we find what was described as a peculiar form of Sinusoidal alternator, constructed by Prof. A. B. Kennelly, which consisted of a circular layer of spools which were composed of two separate coils, an inner one with eight layers of fine wire and the outer one two layers of coarse wire, the inner coil connected in series constituted a secondary coil, while the outer coil connected with another series and formed the primary coil of the apparatus. The continuous current was connected directly to the primary coils and the

FIG. 94.—MULTIPLEX SINUSOIDAL APPARATUS.

armature composed of laminated magnet iron. The armature which had six projections was connected with a pulley to be run by a small motor. When the armature was made to revolve, the primary coils, having a current circulating through them, magnetized the field magnets; the magnetic lines of force thus produced remained stationary in the field as long as the armature was stationary, but as soon as the armature began to rotate the lines of force shifted from one side of the magnetic field to the other and cut the current

in the wires of the secondary coils, first one side then the other, that produced a current known as the *sinusoidal* delivered from the secondary coil through conducting wires to the patient."

"Dr. Morse, appreciating the virtues of the Kennelly apparatus and realizing its defects from a practical standpoint, has carried out the same principle only in the construction, which has rearranged the original coils, making

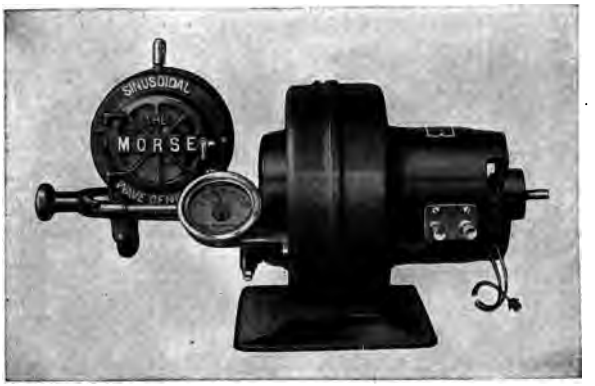


FIG. 95.—MORSE APPARATUS.

the armature many times larger and more powerful, and when in operation the magnetic lines of force through automatically arranged induction can be made coming from a 12-inch diameter as compared with the original Kennelly 3-inch diameter induction area, thus rounding out the true sinusoidal and all other selective waves as may be indicated and used in its application. The machine delivers a current of 21,000 alternations per minute, which reduces the skin resistance to a minimum, allowing all forms of mechanical manipulation, superficial or deep, mild or powerful, without causing the least amount of redness to the skin."

"An unlimited number of wave variations can be selected by the use of one of this instrument's special features, viz., *cams,* so much used in other mechanical devices, which arrangement makes it possible to produce contractions varying alternately in any desired length and interval between the surging effects. For instance, in treating subacute bronchitis a surging current can be put through the lungs at a respiratory rate of 18 per minute, so the same principle is carried out from 10 to 60 surging waves per minute, according to the particular muscle or muscles one wishes to synchronize."

This apparatus seems to enable us to induce normal motor impulses by electrical means. It is not intended for the generation of the simple "slow sinusoidal" or the "surging galvanic." By varying the shape of the cams a wave of any desired form may be superimposed upon the rapid sinusoidal current.

CHAPTER XII

INDIRECT USES OF ELECTRICITY

1. These are often classified as electro-therapeutical methods, although they properly belong in the class of physical therapeutic agents. In them the electricity is merely used to generate some other force which is the active therapeutic agent.

2. We may briefly describe "the therapeutic lamp," often called the "Leucodescent lamp"; the electrical "vibrator";

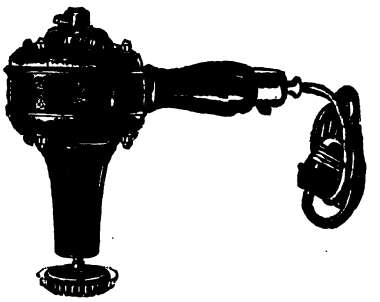


FIG. 96.—PORTABLE VIBRATOR.

the "quartz lamp," for the therapeutic use of "ultra-violet rays," and the apparatus for the generating of ozone and ozone nebula.

3. The therapeutic lamp usually consists of one or more high candle power carbon filament incandescent lamps grouped together in a large parabolic hood or reflector (see illustration). A small portable lamp sometimes used is also shown. The therapeutic effect is due principally to radiant heat. It is of value in allaying muscular pain, and in the relief of local congestion and inflammation.

4. The electro-mechanical vibrator is used for massage effects. A good vibrator should be adjustable for both a "rubbing stroke" and a "hammer stroke," and should be provided with a motor rheostat to vary the rapidity of the vibrations. Those who wish to use the vibrator scientifically

FIG. 97.—SMALL THERAPEUTIC HAND LAMP.

are advised to study Dr. Arnold Snow's excellent work on "Mechanical Vibration."

5. All are familiar with the long tubes of white light seen in photographers' windows—the "Cooper-Hewitt mercury arc lamp." These generate intense ultra-violet rays, but these finer vibrations do not pass through glass. If the lamp be made of pure silica (fused quartz-ware), however, the

ultra-violet rays will be transmitted and may be used therapeutically.

Their use is indicated in cases of alopecia, lupus, epithelioma, and certain other forms of skin disease.

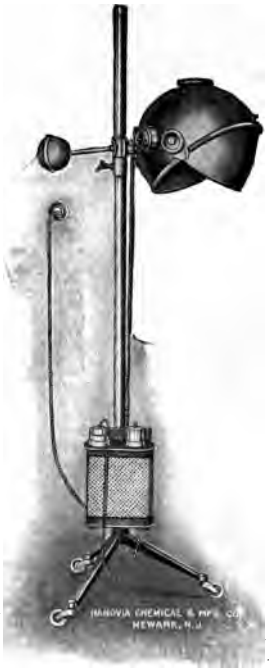


FIG. 98.—ALPINE SUN QUARTZ LAMP.

6. When a high voltage discharge passes through air, the effluve or sparks cause some of the oxygen molecules to split up and rearrange themselves in molecules having three atoms of oxygen instead of two. Three-atomed oxygen molecules constitute "ozone." As generated by sparks in air, it is usually mixed with nitrous vapors which result from the

combustion of the oxygen and nitrogen; these nitrous vapors are irritating if inhaled, so electrically produced ozone is

FIG. 99.—LARGE THERAPEUTIC LAMP.

usually passed through oil of pine needles and eucalyptol before being inhaled. These oils not only absorb the nitrous

vapors, but volatilize in combination with the ozone, producing an unstable product of high antiseptic value when

FIG. 100.—VIBRATOR GIVING BOTH "HAMMER" AND "RUBBING" STROKE.

inhaled. This at least is the claim of those who use and advocate the "Oxylene" apparatus, and certainly the many

FIG. 101.—OZONE NEBULA APPARATUS.

well-known authorities who use and recommend the "ozone nebula" must have some basis for their favorable opinion

Fig. 102.—High-Frequency Apparatus for X-Ray and Therapeutic Use.

of this therapeutic agent. It is usually employed in connection with other forms of electrical treatment for pulmonary tuberculosis, chronic bronchitis, catarrh, etc.

CHAPTER XIII

SPECIAL THERAPEUTICS

ABSCESS. Acute abscess with free drainage: chlorine ionization with salt solution, followed by Tesla treatment with X-ray vacuum electrode. *Incipient abscess* may often be avoided by use of ordinary vacuum electrode. Fulguration often prevents scars.

ACNE VULGARIS. Tesla currents with X-ray vacuum electrode.

ACTINOMYCOSIS. X-ray, supplemented by high-frequency sparks, three times a week. (Eberhart.)

ALCOHOLISM, acute. Auto-condensation, 1,000 ma. until sweating is produced. Vacuum condenser electrode with Tesla current on solar plexus.

ALOPECIA. Ultra-violet treatment from quartz lamp, and Tesla treatment with low vacuum electrode. Thorough massage of scalp with mechanical vibrator and frequent shampoos with mild antiseptic soap.

AMENORRHEA. Negative galvanism with vaginal electrode, 30 ma. for 10 minutes three times weekly. Mild auto-condensation, Tesla vacuum treatment, and mechanical vibration.

ANÆMIA (with low blood-pressure). Mild auto-condensation, vacuum condenser electrode over solar plexus and spine.

ANEURISM. This is a condition in which electro-therapeutic treatment should never be given except by an experienced specialist, by whom mild auto-condensation may be given in suitable cases.

ARTERIOSCLEROSIS, and conditions accompanied by high blood pressure. Auto-condensation, daily treatments if possible: 25 minutes, 800 ma. Regulate the diet, eliminate tobacco, alcohol and red meats; watch the blood-pressure carefully, also the kidneys. The ideal treatment for advanced cases—especially where interstitial nephritis is present—is mild auto-condensation (not over 400 ma.), administered in the patient's home, ten-minute treatments twice daily. Both systolic and diastolic pressure should be frequently taken, and if the pulse pressure—(which is the difference between the two)—falls below 20 mm., auto-condensation should be given less frequently.

ARTHRITIS DEFORMANS. Some success has been reported by the use of the X-ray high-frequency electrode in arresting the progress of the disease.

ARTHRITIS (gouty). Diathermy (as above), alternated with lithium salicylic ionization: cotton-covered electrodes soaked in solution of lithium salicylate with constant current, 20 to 30 ma. for twenty minutes; reverse the current after ten minutes.

ARTHRITIS (rheumatoid). Diathermy, daily treatments, block-tin electrode around each wrist, patient holds thumb and fingers of one hand around each affected joint, current passing from one wrist to the other through the fingers: 1,000 to 1,500 ma. for five minutes through each affected joint.

ARTICULAR RHEUMATISM (see Rheumatic Fever).

ASPHYXIA. Interrupted galvanic, or slow sinusoidal treatment over spine and respiratory centers.

ASTHMA. Ozone inhalation and Tesla effluve tends to relieve the paroxysms; diathermy through the lungs, and auto-condensation.

ATAXIA, LOCOMOTOR (see Tabes).

BRONCHITIS (acute). Diathermy through affected lung,

ozone inhalation and therapeutic lamp varied to suit individual cases.

BRONCHITIS (chronic). Tesla effluve over chest, auto-condensation with block-tin over the affected area instead of hand electrode.

CARBUNCLE. X-ray electrode with Tesla current; chlorine ionization from negative pole, continuous current. Fulguration.

CATARACT. Absorption in early stages has been obtained by Tesla low vacuum eye electrode, short treatment twice daily if possible, diathermy twice a week; patient on auto-condensation couch, block-tin to one wrist, two fingers of the hand being used to conduct the current through the lid of the affected eye.

CERVIX (inflammation and erosion of). Positive ionization with zinc or copper-tipped vaginal electrode, also Tesla currents through insulated vaginal vacuum electrodes.

CHANCROID. Chlorine ionization (see ulcers). Fulguration with vacuum sparks has also been successfully employed.

CHOREA. Static sparks and Tesla effluve over spine.

COLD EXTREMITIES. This distressingly common condition is usually due to vaso-motor insufficiency; this yields readily to auto-condensation supplemented by static wave current or bipolar Tesla treatment with effluve over solar plexus.

CONSTIPATION. Slow sinusoidal current and mechanical vibration over the colon, with the daily use of the "Internal Bath" (so-called "Cascade"), auto-condensation with block-tin electrode over the abdomen.

CORYZA ("Cold in the Head"). Diathermy applied by means of wrist electrode, the nose being held between the thumb and finger, patient seated on the condenser couch; nasal vacuum electrode applied alternately for five minutes in each nostril.

CYSTITIS. Bipolar Tesla treatment, metal electrode over suprapubic region, vacuum electrode in urethra, rectum or vagina; diathermy is also indicated, especially in chronic cases.

DEAFNESS. If of catarrhal origin excellent results are often obtained by the use of the Tesla vacuum electrode in the ear with mild vibratory treatment. Dr. Yates reports excellent results by the use of the static current, passed directly through from one ear to the other, by means of large metal ball electrodes pressed closely to the ears. In atrophic cases, diathermy with block-tin electrode on each wrist and the little fingers in each ear as electrodes.

DIABETES. Eberhart reports excellent results with auto-condensation with daily treatments diminished in frequency as the percentage of sugar in the urine decreases.

DYSPEPSIA. Auto-condensation, sinusoidal currents, Tesla vacuum condenser electrode, varied according to the nature of the individual case.

EARACHE. Diathermy by the indirect method as given under "Deafness," Tesla vacuum ear electrode.

ECZEMA. X-ray high-frequency electrode, also iodine ionization—(potassium iodide solution from negative electrode, constant current).

EPILEPSY. Tesla vacuum condenser electrode on base of brain, spine and solar plexus with mild auto-condensation has been found helpful in diminishing the frequency and severity of the attacks. Where constipation exists it should be corrected by treatment as given under that heading.

EPITHELIOMA. Small incipient growths may be destroyed by negative electrolysis or fulguration; more advanced growths should be treated by metallic ionization (Massey's method). Always followed by careful X-ray treatment to destroy deeper foci; X-ray vacuum electrode with Tesla

current is the safest for those who are not experienced in the use of the X-ray.

EXOPHTHALMIC GOITRE. X-ray vacuum electrode with Tesla current on neck and base of brain. Positive galvanism and positive static insulation on alternate days (Neiswanger).

GASTRITIS. Diathermy, Tesla vacuum condenser treatment, or slow sinusoidal, according to the nature of the case.

GLAUCOMA. Indirect diathermy (for technique see "Cataract").

GLEET. Indirect diathermy; Tesla vacuum electrode applied through rectum.

GOITRE. Tesla current with X-ray condenser electrode over the enlarged gland alternated with iodine ionization (potassium iodide solution applied from negative electrode, 15 to 20 ma. for twenty minutes).

GONORRHEA. Indirect diathermy used in addition to ordinary method of treatment.

GOUT. Auto-condensation—begin with small dose, 300 to 400 ma. three times a week, increasing dose up to 800 ma. and assisting elimination by the use of simple diuretics. Lithium salicylic ionization and diathermy applied to the affected joints (see "Arthritis").

GRAY HAIR. Eberhart reports cases in which the hair has been restored by the persistent daily use of high-frequency sparks from vacuum electrode supplemented by mechanical vibration and an occasional X-ray treatment. As even mild X-rays have a marked depilatory action in certain cases; great caution should be observed in their use, as even a gray head is preferable to a bald head!

HAY FEVER. Nasal vacuum electrode treatment and ozone inhalation have been recommended.

HEADACHES. If of a functional character and of the congestive type, Tesla vacuum treatment and indirect diathermy, supplemented by general auto-condensation with

mild current. If the headache is of the neuralgia type, treat as for "Neuralgia."

HEMORRHOIDS (internal). Copper ionization with bulb-shaped copper anode in contact with the sphincter (Neiswanger). For *external hemorrhoids* negative electrolysis, surgical diathermy (electro-coagulation), or fulguration with Tesla sparks.

HERPES ZOSTER. Tesla vacuum treatment often relieves pain and hastens recovery.

HYPOTENSION (low blood pressure). Unless due to organic disease, tonic treatments by Tesla effluve over solar plexus and static wave current with vibratory massage of appropriate spinal areas are indicated. Static auto-condensation with thick dialectric has also been recommended.

IMPOTENCE. Tesla vacuum treatment over suprapubic and sacral regions and in rectum, with indirect diathermy applied over genitals.

INFANTILE PARALYSIS. In the acute stages excellent results have followed the use of the high-power incandescent lamp applied over the spine. The after-treatment includes use of sinusoidal current, Tesla vacuum treatment, and vibratory massage. Diathermy will help to increase nutrition in the atrophied muscles.

INSOMNIA. Tesla auto-condensation with vacuum electrode over cortex and base of brain, alternated with general low voltage auto-condensation.

IRITIS. Vacuum eye electrode, indirect diathermy, in addition to the usual treatment.

LARYNGITIS. Tesla vacuum treatment, ozone inhalation with diathermy.

LEUCORRHEA. Vaginal vacuum electrode and hot antiseptic douches.

LOCOMOTOR ATAXIA (see "Tabes").

LUMBAGO. Tesla vacuum electrode over the affected muscles, diathermy with one electrode on either side of spine, therapeutic lamp. Eberhart also recommends high-frequency sparks and mechanical vibration.

LUPUS. X-ray treatment, Tesla X-ray electrode, ultra-violet rays from quartz lamp.

MENORRHAGIA. Positive galvanism with vaginal electrode, diathermy.

MIGRAINE (see Headache).

MOLES. Negative electrolysis, fulguration.

NASAL CATARRH. Nasal vacuum electrode, indirect diathermy, ozone.

NEURALGIA. Diathermy, Tesla vacuum electrode, bipolar Tesla sparks in obstinate cases.

NEURASTHENIA (Nervous Exhaustion). Tesla vacuum electrode over solar plexus, static or high-frequency sparks over spine, Tesla effluve, auto-condensation if blood pressure is high.

NEURITIS. Local auto-condensation or diathermy. Neiswanger recommends the Morton wave-current; persistent treatment is necessary in these cases.

OBESITY. Auto-condensation up to 1,200 ma. twice a week. Bergonie's method with special faradic currents is largely used by specialists.

OTITIS. Vacuum treatment in addition to appropriate local treatment.

PAPILLOMA (see Moles).

PARALYSIS. If of cerebral origin mild diathermy from forehead to base of brain will sometimes assist nature in absorbing the embolus. Mild galvanism applied in the same way has been used: positive pole over forehead; great caution is necessary, for if we produce active cerebral hyperæmia we may cause a second cerebral hemorrhage. If the paralysis is of spinal origin, or in hemiplegic cases of

long standing, massage, sinusoidal, interrupted galvanic, diathermy and wave-current are used over the affected muscles.

PLEURISY. Therapeutic lamp, diathermy in acute cases; local auto-condensation and X-ray vacuum in chronic cases.

PNEUMONIA. Diathermy, therapeutic lamp, ozonized oxygen.

PRURITIS. Vacuum sparks and Tesla effluve.

PSORIASIS. X-ray, Tesla effluve.

RHEUMATISM. Therapeutic lamp, diathermy in acute rheumatism (for chronic muscular rheumatism, see Lumbago).

SCARS. Chlorine ionization, fulguration, cataphoric use of solution of thiosinamin 5%, driven in from the positive pole; galvanic current.

SCIATICA (see Neuritis).

SPRAINS. Diathermy, Tesla low-vacuum treatment.

STRICTURE OF URETHRA. Negative electrolysis (see chapter on Galvanism).

TABES DORSALIS (Locomotor Ataxia). Static or Tesla sparks over spine, diathermy, auto-condensation will in many cases relieve pain and retard the progress of the disease.

TONSILLITIS. Diathermy externally.

TUBERCULAR GLANDS. X-ray vacuum sparks, diathermy.

TUBERCULOSIS (pulmonary). X-rays over the affected lung, local auto-condensation, ozone nebula, Tesla effluve over back and chest. Gibson recommends static treatment also.

ULCERS. Chlorine ionization:—a glass cylinder open at both ends is placed over the ulcer and sealed around with "plasticine"; the cylinder is then filled with 5% salt solution in which a platinum cathode is immersed. This method is being extensively used in the War Hospitals.

URIC ACID DIATHESIS (see Gout).

VARICOSE ULCERS AND RODENT ULCERS are treated as above with supplementary use of the X-ray and ultra-violet ray.

WARTS (see Moles).

X-RAY BURNS. These arise from faulty technique in the use of too strong doses of X-rays or from radiographic accidents. Immediate use of low-vacuum condenser electrode with Tesla current over the treated area after every exposure to the X-rays will in most cases prevent any serious destructive effects from the X-rays when properly employed.

APPENDIX TO CHAPTER ON DENTAL ELECTRO THERAPEUTICS.

The illustrations and descriptions in this appendix are taken from a monograph entitled, *"Radiographic Interpretations of Abnormal and Pathological Dental Conditions,"* and are published by the courtesy of the author, Dr. Jacob J. Lowe, Managing Director of the Boston Dental X-ray Laboratory.

"The purposes of this monograph are threefold:

First. To show a few abnormal and pathological dental conditions, any of which may be the cause of or a contributing cause of, systemic disturbances, such as arthritis, headache, rheumatism, neuritis, neuralgia, sciatica, gastric and duodenal ulcers, cardiac lesions, neurasthenia, iritis, etc.

Second. To enable the physician and dentist to better recognize (from an X-ray standpoint) the more common pathological conditions, dental abnormalities and mechanical mistakes. In each instance the physician or dentist can determine the proper method of procedure.

Third. To give the physician and dentist an idea of the character, scope and importance of dental X-ray work. The X-ray will, in the majority of instances, if the correct technique is employed, record on the photographic film any abnormal or diseased condition which may be present beneath the surface.

The destruction or thinning of the process, either from advanced age, disease or surgical procedure; cavities such as the antra or nares; pathological conditions such as abscesses,

cysts, fistulas, etc., nearly always will be evidenced by a dark area on the film. They offer little resistance, and therefore permit the greater portion of the X-ray to penetrate the tissue to the film. Likewise and for the same reason do the root canals show dark as compared with the walls of the teeth. This is especially noticeable in children. Healthy tissue has more resistance to the X-ray than has diseased tissue, therefore more of the X-ray strikes the film through the diseased tissue than through the healthy tissue; consequently, the portion of the film behind the diseased tissue will be darkened as compared to the portion of the film behind the healthy tissue, teeth, fillings, crowns, foreign bodies, etc.

In root canal investigation it is advisable, when possible, to insert a broach, wire or temporary filling before the patient is referred for the dental X-ray examination. By this method the length, size and direction of the canal can be shown more plainly. By using a "soft" filling (bismuth paste) side wall perforation can also be evidenced.

The following illustrations are reproduced from the original films and not from prints thereof. The resulting halftones are the same as though one were looking at the original films by transmitted "light."

D 1. PERFORATION OF APICES—ABSCESS

Region:

Upper centrals.

X-Ray Findings:

1 Arrows indicate the extent of apex perforation by canal fillings.
2-3 Pronounced areas of involvement.

Remarks:

Patient, woman, reported a medical diagnosis of rheutoid arthritis. Canal filling of long standing. Systemic trouble of comparatively recent occurrence.

D 2. ABSCESS—BROKEN INSTRUMENT

Region:

Upper centrals-right lateral area.

X-Ray Findings:

1 Broken broach. Root canal unfilled.

Remarks:

Patient referred to determine cause of painful, infected area over right lateral.

D 3. ABSCESS

Region:

Lower central-lateral area.

X-Ray Findings:

Abscess involving both centrals and left lateral area.

Remarks:

Patient had a discharge on the lower right (external) side of jaw. Probe (arrow 1) was introduced into sinus and broach (arrow 2) inserted in right central. Root amputation of all involved teeth was performed.

D 4. CARIES

Region:

Upper left central.

X-Ray Findings:

1 A carious cavity is shown, under gum margin, which has left the walls of the canal intact.

Remarks:

This is a rare condition, inasmuch as the tooth in question was alive and the cavity could not be located. The process in the central-lateral region had been absorbed to quite an extent. More or less infra-orbital pain was the only symptom given by the patient.

D 5. ABSCESS—SPLIT ROOT

Region:

Upper right bicuspid-molar area.

X-Ray Findings:

A-B. Sections of split root of second bicuspid and pronounced area of involvement. Also note abscess at end of roots of first bicuspid and molar.

Remarks:

Patient suffering from severe headaches. Removal of both bicuspids and drainage of infected molar area afforded relief.

D 6. FOREIGN BODIES

Region:

Lower right molar area.

X-Ray Findings:

1-2-3 Broken instruments.
4 Inflammation. Root canals unfilled.

Remarks:

Patient referred by throat specialist to dentist, for consultation, to determine cause of persistent pain in molar region.

D 7. MALPOSED, UNERUPTED CUSPID

Region:

Upper left central-molar area.

X-Ray Findings:

1 Malposed, unerupted cuspid.
2 Process involvement. There is also an area of involvement over the second bicuspid.
Note curve in both bicuspid roots.

Remarks:

Patient, boy, age 19. Putrescent discharge in cuspid region. Headaches with spells of dizziness. Presence of unerupted cuspid unsuspected.

D 8. UNERUPTED MOLAR

Region:

Upper left molar area.

X-Ray Findings:

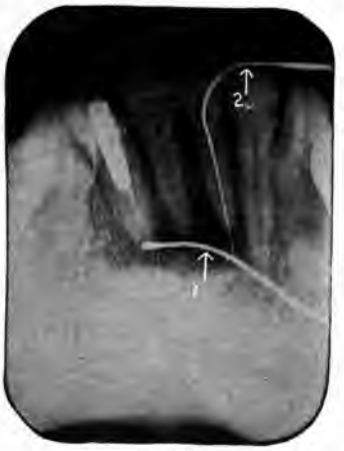
Arrow indicates impacted, unerupted, third molar.

Remarks:

Patient, man, age 50. Neuralgic condition relieved by removing point of impaction and permitting eruption of molar. Note abscessed condition around apices of first molar.

D1

D2



D3

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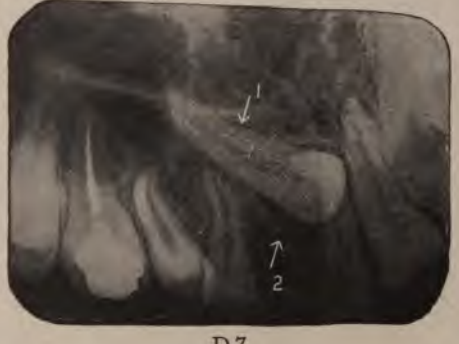

D7

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D 9. IMPACTED, UNERUPTED MOLAR

Region:

Lower right molar area.

X-Ray Findings:

Arrow indicates degree of impaction of unerupted third molar.

Remarks:

Patient, girl, age 19. Pronounced dark area surrounding unerupted molar is probably not diseased and may be a natural cavity in the cellular process. In a number of instances, the surrounding tissue of an impacted, unerupted tooth will be inflamed.

D 10. CARIOUS IMPACTED, UNERUPTED THIRD MOLAR

Region:

Upper left molar.

X-Ray Findings:

1 Unerupted molar.
2 Cavity.
G-L. Gum line.

Remarks:

Patient, woman, age 65, suffering from constant acute headaches with a pronounced drooping in the region of the left eye. Frequent attacks of wry neck. Extraction refused. Relieving of point of impaction caused immediate relief.

D 11. PYORRHEA POCKETS

Region:

Upper left bicuspid-molar area.

X-Ray Findings:

1 Abscess at apex of first bicuspid. Note involvement of apex of second bicuspid.
2-3 Partial destruction of sockets of first and second molars.

Remarks:

Note that while the first bicuspid is crowned and the first and second molars are carrying large fillings, none of the canals are filled. Patient, man, age 55. Rheumatism.

D 12. ABSCESS—ROOT ABSORPTION

Region:

Lower left molar area.

X-Ray Findings:

1 Large cavity in first molar.
2 Area of involvement. Process involved between roots. Apex of mesial root absorbed.

Remarks:

Patient, girl, age 19. Clinical diagnosis (medical), pernicious anemia.
Note area of involvement around roots of second molar. Also note unerupted third molar which is impacted.

D 13. PUNCTURED APEX—EXOSTOSIS

Region:

Upper right cuspid-molar area.

X-Ray Findings:

1 Apex of cuspid punctured with inflammatory condition present.
2 Slight degree of involvement over apex of first bicuspid. Canals unfilled.
3 Arrows indicate exostosed condition of second bicuspid. Canal unfilled above post.

Remarks:

Patient, woman, age 40. Severe neuralgic headaches with an aftermath of numbness in region of right eye and temple.

D 14. RETAINED ROOTS—ABSCESS

Region:

Upper left lateral-molar.

X-Ray Findings:

1 Pronounced area of involvement in lateral region. Apex of lateral absorbed.
2 Involved area around apex of first bicuspid.
Note distinct appearance of both bicuspid roots. Probably these roots have become turned in their socket.
3 Two retained molar roots which appear to be fused. Socket somewhat involved.

Remarks:

Dark area above arrow 3 is a portion of antrum.

D 15. ROOT AMPUTATION

Region:

Upper left bicuspid-first molar.

X-Ray Findings:

1-2 Roots lost after operation. Dark area may be diseased or the result of surgical procedure.
3 Slight inflammation at apex of mesial root of first molar.
4 Gold band to hold fracture in crown of first molar. Fracture not shown in this view.

Remarks:

Patient, woman, complained of severe pains in bicuspid region for some time after operation was performed.

D 16. TEMPORARY MOLAR—SECOND BICUSPID MISSING

Region:

Lower right second bicuspid-molar area.

X-Ray Findings:

1 Temporary molar occupying second bicuspid space, second bicuspid missing.
2 Tip of unerupted, impacted third molar.

Remarks:

Patient, man, age 42. Acute pain followed by numbness in molar region. Presence of temporary molar and an unerupted wisdom unsuspected.

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